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THE
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DARWIN CENTENNIAL NUMBER

PHILOSOPHICAL ADVENTURES OF THE IDEA OF EVOLUTION: 1859-1959
JAMES STREET FULTON

EVOLUTION, TELEOLOGY, AND HISTORY
RADOSLAV A. TSANOFF

THE SUPERNATURAL NATURALISM OF DREISER'S NOV~~ELS~~
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Busycon perversum (Linné) AND SOME RELATED SPECIES
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NOTES ON THE ORIGIN OF BONY ARMOR
H. J. SAWIN

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PROŒMIUM DE ANNO MIRABILI

NOWADAYS we hear much of gifted children (not to be confused with exceptional children, for in the jargon of educators "exceptional" means exceptionally bad). There are also gifted years. The present number of *The Rice Institute Pamphlet* celebrates the centennial of such a year: 1859.

One aspect of gifted years can be illustrated by another date, exactly a half-century earlier: 1809 (QUERY: Do gifted years run in fifty-year cycles?) It deserves to be known in the history of the nineteenth century as "the year of the great birth," for a really astonishing number of major Victorians, both English and American, were born in that year. In England they included the poet laureate, Lord Tennyson, the dean of biologists, Charles Darwin, and the great prime minister, Gladstone; not to mention luminaries of secondary magnitude, such as Edward FitzGerald. In America there were Edgar Allan Poe, President Abraham Lincoln, Autocrat Oliver Wendell Holmes—but why go on? Curiously, if a great Victorian was not born in 1809, it is almost safe to assume that the birthdate was 1819. (QUERY: Is there a ten-year epicycle for gifted years?) Consider John Ruskin, George Eliot, Charles Kingsley, James Russell Lowell, Herman Melville, and Walt Whitman, all born in 1819. Emily and Anne Brontë somewhat tactlessly came into the world in 1818 and 1820, but then none of the Brontës were well adjusted. Needless to say, the birth year of both Queen Victoria and Prince Albert was 1819.

But what of our centenary *annus mirabilis*, 1859? (QUERY: Is the digit 9 a magical number for gifted years?) First, let it be admitted that so far as the United States was concerned, 1859 was distinctly an "exceptional" (i.e., exceptionally bad) year. Americologists have unearthed the fact that Holmes' *Professor* appeared then (but dated 1860) and that Joseph Jefferson began his celebrated performances of *Rip Van Winkle* in 1859, but they report little else of cultural interest. Seemingly, the momentous Lincoln-Douglas debates of the preceding year, followed by the hanging of John Brown on December 2, 1859, caused America to bate its national breath in hushed expectation of the election and secession of 1860-61.

In England, on the contrary, never were greater gifts showered by a single year. Greatest of all, in retrospect, was *The Origin of Species by Means of Natural Selection.* Charles Darwin did not, of course, "discover" evolution. The evolutionary processes of nature had been observed by the Greeks; the term "survival of the fittest" was supplied by Herbert Spencer (as Darwin willingly acknowledged); and the cardinal principle of natural selection was announced conjointly by Darwin and a younger naturalist, Alfred Russel Wallace. Charles Darwin's genius was concentration: his was the burning glass that brought to a focus the population theory of Malthus, the new geology of Lyell and von Humboldt, and the germinal evolutionary studies of Lamarck, of his own grandfather Erasmus Darwin, and of other predecessors and contemporaries. When this centennial issue of *The Rice Institute Pamphlet* was proposed to commemorate the year 1859, the ramifying effects of Darwinism in philosophy and literature as well as in biology and paleontology were unanimously selected as the most obviously appropriate theme.

Another great book of 1859, one of our two classic statements of the doctrine of liberty of thought and expression, was John Stuart Mill's essay *On Liberty.* In contrast with Milton, whose *Areopagitica* impels by passionate utterance more than it convinces by logical analysis, Mill is dry and matter-of-fact. Derided by Carlyle as a logic-chopping machine, like the Mill of the Gods he chopped slowly and exceedingly fine. However, with a vision wider even than Milton's, he broadened his scope to a general defense of the individual and of minorities against society, the state, the compact majority. His arguments are eminently fair, winningly candid, and very nearly irrefutable.

The year 1859 is also important for creative literature, including publication of the first four *Idylls of the King*. It is passing wonderful that England, the sceptered isle graced by generations of able poets, has never really had a national epic. *Beowulf* is wholly oriented toward the Continent. *Paradise Lost* is the epic, not of an ethnic people, but of mankind, the human race. If finished, *The Faerie Queene* might well have qualified as a—perhaps the—British national epic, but it is a fragment. The truth is that despite the deficiency of Tennyson's poem in Virgilian machinery (apart from its saving final organization into twelve books), it is one of the strongest competitors for the vacant title of national epic ever produced by an English poet.

In fiction, few years can rival 1859 for the distinction of *Adam Bede, The Ordeal of Richard Feverel,* and *A Tale of Two Cities.* The last is one of Charles Dickens' best books; its relegation to the class of *The Last of the Mohicans* by having been placed on "required reading" lists has subjected it to the same unfair devaluation that has befallen "L'Allegro" and "Il Penseroso," *Julius Caesar,* and Gray's "Elegy." As is well known, it has a firmer plot structure than most of the novels of Dickens; in addition, an unpublished study by a graduate student at the Rice Institute recently has shown its remarkable artistry of diction, imagery, and sustained symbolism. George Eliot's *Silas Marner* has likewise been degraded to set reading lists but, fortunately, not *Adam Bede,* which is a better and more substantial book. "Substantial" seems altogether the right word for George Eliot. The language of *Adam Bede* does not shimmer and coruscate. Its author's homely countenance launched no ships, and her birthday—even though it occurred in a "gifted year," 1819—never will be celebrated by dancing in the streets. She is as plain, yet as strangely attractive, as the Dutch genre paintings that delighted and inspired her by their truthfulness.

Along with Henry James, George Meredith was a principal link between the traditional novel and the new departures in style, psychological analysis, and point of view that have characterized recent fiction. Like James, Meredith often seems deliberately to lay roadblocks in the pathway of uninitiated readers, who may feel the same kind of gratitude for *Richard Feverel* as for *Daisy Miller:* it is easy (or, at least, comparatively undifficult), and withal it tells an excellent story. Nevertheless—again like Henry James—Meredith is strictly a writer for adults. He has nothing to offer children, the mentally retarded, or persons brainwashed by soap-opera.

Another work of the *annus mirabilis,* 1859, is of such ambiguous nature that no one dares to say categorically whether it is a translation or an original poem. Edward FitzGerald's imitation, or adaptation, or paraphrase, or translation of *The Rubáiyát of Omar Khayyám* is a palmary exhibit in the Museum of Comparative Literature. Feeling no compulsion to render literally the manuscript from which he worked, by normalizing the meter and rime scheme and regularizing the sequence of stanzas FitzGerald re-created his Persian original with what a teacher of rhetoric might laud as improved unity, coherence, and emphasis. Although very nearly stillborn on first publication, it was roused to vigorous life by the trumpets of Aestheticism. In puffed artificial-leather bindings, it then lay incongruously beside *In Memoriam* on late-Victorian marbletop tables, singing consolations of despair antiphonally with the poet laureate's consolations of faith. In the pockets of American students, it went surreptitiously to college; and in the handbags of commercial travelers, it traversed the cities of the plain. For two or three generations it was the unholy writ of the beautifully damned, a Baedeker's pocket-guide to the primrose path. Today it is read nostalgically by elders who once were youths, but youth knows it no more.

As for births and deaths of 1859, we see simultaneously the passing of the Romantic period in the death of Thomas De Quincey and Leigh Hunt, and an unseasonal harbinger of Victorian autumn in that of Macaulay. Most of the Romantics had died young and innocent of Victorianism, but Hunt and De Quincey lingered on until Tennyson had succeeded Wordsworth, and the birth of four Princes and five Princesses had seemingly engraved the new era upon eternity. Thomas Babington Macaulay not only saw the advent of that age; he was its son and heir, and its unashamed advocate—the very embodiment of the Victorian Compromise. He was also one of the great men of letters of his time, and so admirably true to his bookish nature that when he suddenly expired on December 28, 1859, he died reading a book.

In the generations, as in all else, for every action there is the reciprocal reaction; if in 1859 an old world was passing, a new world was coming into existence. Francis Thompson, who was born in the same year when Thomas De Quincey died, like De Quincey fell victim to opium; but he was also the quarry of the Hound of Heaven, and one of the two great Roman Catholic Victorian poets. Another birth of 1859, that of A. E. Housman (how odd to think of him as ever a baby!) launches us more directly toward the twentieth century. Housman's verses have enjoyed, and still enjoy, a vogue mildly similar to the former cult of the *Rubáiyát*, but one more likely to endure because of their remarkable power of Katharsis, of cleansing and refreshing the spirit. Finally—or, to turn a phrase, last but not least—there arrived in 1859 one Arthur Conan Doyle, in after years to be known as a physician, a writer of historical tales, and a spiritualist, but above all as the creator of Sherlock Holmes and the prototype of Doctor Watson. With Housman, Doyle may very well have achieved the happy destiny of living classic, to be read with delight by all ages in all times.

ANNUS MIRABILIS, verily, was 1859: *a year of wonders.*

J. D. T.

PHILOSOPHICAL ADVENTURES OF THE IDEA OF EVOLUTION: 1859-1959

I

AN ESSAY on the philosophy of evolution in the century since the publication of Darwin's *Origin of Species*[1] can be written in two sentences. By the end of the first fifty years, everybody in the educated world took evolution for granted, but the idea was still intellectually exciting and its philosophical exploitation was entering upon its period of full maturity. By the end of the next fifty years, evolution belongs to "common sense" almost as thoroughly as the Copernican hypothesis and other early landmarks of the scientific revolution; but the idea is no longer exciting, and evolutionary philosophy is out of fashion.

The following pages will trace the adventures of the idea of evolution primarily in its second fifty years. The first fifty years were the heroic age of the idea, when it was fervently propagated by confident believers, ready and willing to do battle against all comers. Many were the dragons of philosophical and theological error slain in heated polemic. By 1909, when John Dewey published the perceptive article, "Darwin's Influence on Philosophy,"[2] he could write of victories won and triumphs assured. His was a story of old error exposed and of new truth to be celebrated.

Dewey could afford to write with confidence. The excitement of Darwin's ideas had fertilized thought and investigation for half a century, in social studies, ethics, and metaphysics no less than in biology. Research could doubtless discover how men who were to lead thought in various fields had come under the spell of particular Darwinian ideas at identifiable stages of their intellectual growth; yet that kind of study may not convey a sense of the full impact of the idea of evolution on thought. Though Darwin's studies, of course, did not originate the idea, they surrounded it with the aura of scientific prestige in a supreme degree. Evolutioned captured the imagination of the literate public and shaped the outlook of countless men who never read a word that Darwin wrote and never achieved a clear notion of what he tried to prove. Evolutionism descended like a flooding rain on the Western mind; it washed everything, penetrated into every crevice, engulfed some opinions and brought life to some that might otherwise have lain much longer dormant. It drenched and drowned and fructified—with the massive impartiality of every great idea. Men suddenly—from our perspective, in 1959, suddenly—found they could no longer think in old ways. Familiar beliefs that had always been accepted without question became simply implausible. Just such a drastic revision of fundamental outlook characterized all the major intellectual revolutions—notably the early Greek, the Christian, the modern (scientific) revolution in ideas. Darwin created for his successors a new world image or "root metaphor," or "absolute presupposition." After 1859—the date is arbitrary to a degree—the older world images ceased to mirror the world to men's minds, ceased to allude to what seemed relevant to proper understanding. The world wore a different look.

If the foregoing account should give anyone the impression of an abrupt or instantaneous change, that would be unfortunate. It goes without saying that the Darwinian revolution did not take place in an instant. Like any other great movement of ideas, it worked its way in the minds of individual men, spreading by a kind of intellectual contagion—or conversion—one mind at a time; but its ultimate triumph was assured. After 1859 there was no turning back. By the end of fifty years, the revolution had been carried through.

It had become "natural" for educated men to view themselves and the world in an evolutionary perspective.

Beliefs may become familiar and customary without being adequately understood; indeed, this is the rule rather than the exception. Adequate analysis and interpretation of ideas, the business of philosophy, comes late because it is difficult. Take any key idea (e.g., substance, form, matter, cause, time, space), and its career will confirm this judgment. The case of evolution is no exception. Men became accustomed to it without clearly grasping either its nature or its implications. Precisely in this obscurity lay the task for philosophy, for a philosopher is a man with one principal eccentricity: he cannot rest until he knows what he believes—in the dual sense of knowing *what* he believes and of *knowing* what he believes. The evolutionary philosopher had to determine what features imparted to the notion of evolution its transforming power (thus defining *what* he believed); and he had to place these features in relation to all other fundamental aspects of the cosmos so as to be assured of the coherence of his various insights (thus coming to *know* what he believed).

On a previous page, Darwinism was compared to the major intellectual revolutions in the history of the Western mind. The comparison referred primarily to the impersonal, massive, almost inexorable sweep of the evolutionary idea; but in scope and basic novelty it hardly belongs in such company. The Darwinian revolution, important as it has been, is no more than an incident in the modern scientific movement. Minds that had already undergone the scientific revolution could take Darwinism in stride without important modification of fundamental assumptions. Of the major innovations this is not true; they alter the whole cast of an epoch's thought.

What Darwin did was to extend the basic scientific attitudes over the whole range of biological phenomena. Scientifically he was conservative, no friend of innovation. He nevertheless had the impact of a revolutionary innovator in ideas and achieved prompt notoriety in a world presumably accustomed, since the Enlightenment of the eighteenth century, to accept the main tenets of the scientific revolution of the seventeenth. We may justly speak of the Darwinian revolution, because Darwin brought home to the nineteenth century some implications of the scientific revolution which startled conventional (i.e., unthinking) minds. There resulted public agitation and heated dispute that impeded impartial philosophical clarification.

The true significance of evolutionism for philosophy, and the real problems which it posed for adequate interpretation, were lost from view in the excitement of doing battle against manifest incompetence. Ignorance once more was fighting and losing a last-ditch battle with critical scientific intelligence;[3] but the folly of the losers' tactics may have prompted the winning side to form an exaggerated estimate of its own merits. The obscurity of its own systematic ideas was not recognized. More importantly, it passed unnoticed that the very notion of evolution contained suggestions of a way of viewing events quite at variance with the mechanistic root-metaphor of the scientific revolution.

The nineteenth century brought the idea of evolution into the center of intellectual ferment. Before Darwin, Herbert Spencer had attempted a systematic evolutionary philosophy. He exploited the notion of evolution that, from the time of Erasmus Darwin and Lamarck in the eighteenth century, had enjoyed a more or less lively existence on the speculative fringes of European thought. Charles Darwin himself delayed little in drawing far-reaching philosophical conclusions about human morals and progress. Neither Darwin nor Spencer perceived all the philosophical implications of their central idea. They performed well the service of spreading the notion of evolution, but its adequate critical treatment had to await the twentieth century.

By a delightful coincidence, three of the most original interpreters of the idea of evolution in philosophy were born in the very year of publication of *The Origin of Species,* 1859: John Dewey, the most American of philosophers, prophet of experimental intelligence as the avenue to human welfare; Henri Bergson, the brilliant French interpreter of the creativity of evolution; and Samuel Alexander, the Australian-English realist philosopher of boldly speculative power, who attempted a unique synthesis of evolutionary and relativistic cosmology. A fourth and slightly later philosopher of the first rank who may be considered to have made fundamental contributions to the philosophy of evolution was Alfred North Whitehead. But in his philosophy the idea of evolution had already retreated into the background, being absorbed into and partially disguised, if not superseded, by the idea of organism. It is taken up into and transmuted by a philosophical construction that with profound originality brings the philosophy of emergent novelty back into relation with the great Platonic tradition.

By the late twenties, when Whitehead was at the peak of his metaphysical career, the course of philosophy was already turning into new channels. There were two of these, and they were vastly different from each other as well as from the type of philosophy to which the idea of evolution contributes. One channel is that of minute logical, linguistic, or positivistic analysis—a stubbornly epistemological emphasis that shrinks from the extravagance of speculative hypotheses in cosmology. The other channel is that known widely, though vaguely, as existentialism. Every leading existentialist, with considerable justification, refuses to accept the label; existentialism, nevertheless, stands for a temper and style of philosophy strikingly different from that of science-oriented works that constitute much of the philosophical bibliography of the past century. The one channel is basically sceptical, being obsessed by the desire for clear statement and sufficient verification. The other may be sceptical, too—of our *human* values; but it often exploits this emptiness as preliminary to an act of faith. Neither of these philosophical styles lends itself to significant exploitation of evolutionary ideas. One is preoccupied with details of logical syntax or of common verbal usage; the other is absorbed in the predicament each man on earth is in—*is* in. This is the present and only predicament of each, and neither an evolutionary past nor an evolutionary future has anything to offer concerning it.

II

Darwin showed his scientific conservatism by devising a theory of evolution which makes no use of final causes, or purposes. One of the most radical innovations of the modern epoch of thought had been the rejection of final causes in nature. At a stroke, this denial reduced all explanations to mechanistic terms. That fact was already perfectly clear to Descartes, who, boldly consistent, hinted at a cosmic evolution of the physical order we know; he construed living bodies as immensely complex machines and explained their behavior in terms of reflex actions triggered by motions impinging on them from without. It is still the same with philosophers of physical science—however they may debate the exact nature of causality, or the meaning in physics of determinism and indeterminism, or of randomness, none pays a moment's attention to purposiveness. Nor did Darwin do so in constructing his concept of evolution.

It was, in fact, precisely the explanation of evolutionary processes without appeal to final causes that formed the essence of his originality and gave his *Origin of Species* the character of a revolutionary document. In a sense, Darwin said only what scientists had been saying all along. Had he not obtained one of his chief clues from Lyell's studies of the cumulative record of geological changes through ordinary causes? His conservatism had revolutionary impact because he described a *mechanism* of evolution that seemed to account for the empirical facts throughout the entire range of biological phenomena. You have only to assume random minute variations, and natural surroundings making the survival of some of these more probable than survival of others, and you have the mechanism of the origin of species. The seeming purposiveness of the adaptation of living forms to their conditions of life vanishes in a way of looking at them that makes no allusion to ends. In the face of the vast quantity of detailed evidence assembled by Darwin and marshaled in his works, the doctrine of special creation had to be abandoned—that extraordinary blend of bad theology and bad Aristotle. Men suddenly discovered stranger ancestors than Adam. Pious but uninstructed common sense received a shock comparable to that administered by the Copernican hypothesis. Teleology, already excluded from transactions of mere matter in motion, now had to yield the stronghold of living things, seemingly so full of purposes.

To Darwin's credit it may be said that he was not a doctrinaire Darwinian. He seems to have kept a more open mind than some of his followers toward the inheritance of acquired characteristics, and he ended by inconsistently attributing to evolution a tendency toward greater goodness. The consistent core and source of the revolutionary power of Darwin was, nevertheless, the mechanizing and naturalizing of life over its whole range. His simple theory had stupendous systematizing power.

Darwin's scientific conservatism has received most of our attention so far. His naturalism—his methodological assumption that everything in nature has an empirical explanation—offered man a new image of himself, or, more accurately, confirmed and sharpened the modern scientific image of him. This formed, quite understandably, the center about which the storms of controversy whirled. When the storms at length had subsided, leaving only long rollers to disturb the distant shores of backward opinion, some philosophers who had grown up amidst the intellectual excitement of the first generation of Darwinism began to perceive that the idea of evolution had more profoundly revolutionary implications for philosophy than had hitherto been appreciated. They saw the situation in different ways; but they all saw that the idea of evolution departs radically from the characteristic assumptions of modern scientific naturalism. It was evident that the fundamentals of the position had to be re-examined. The re-examination brought evolutionary philosophy to full maturity.

The most fundamental notion that had to be looked at again was time. Evolutionism forced philosophers to "take time seriously," in Samuel Alexander's well-known phrase. This is the sum of Darwin's influence on philosophy at the deepest level. All other problems and attitudes may be considered derivative from it. We shall presently remind ourselves of some of these more special developments in greater detail, but just now it is appropriate to characterize the new feeling for time more exactly.

Traditionally, time had been, philosophically speaking, "always a bridesmaid, never a bride." It was a second-best, as defective as it was puzzling. Parmenides' "way of error," Plato's "moving image of eternity," the Christian scene of the drama of fall and redemption, but primarily the arena of sin and corruption—all treat time as finite, incomplete, futile, and frustrating. Time stood between man and his nature and had to be overcome. Following Hegel's lead, F. H. Bradley, Bernard Bosanquet, Josiah Royce, and numerous other idealist philosophers of the half-century after 1875, considered time unreal. Bradley called it "an appearance which contradicts itself."[4] The Absolute alone is real, and it is eternal. Time is but one of the innumerable, partial, fragmentary, defective appearances of the Absolute to finite beings incapable of fully comprehending the eternally Real. Time—and this is of the essence of pre-Darwinian tradition—defines a zone of twilight existence, neither quite real nor quite unreal, where everything incessantly passes away; true Being, Reality, never passes away but forever is.

The notion of evolution, first implicitly, then expressly, reversed the emphasis. Whatever passes away must first *come-to-be.* "Time" in the twentieth century became the name for coming-to-be rather than for "perpetual perishing." Note how radical the change wrought by stressing the first rather than the second member of the inseparable pair, coming-to-be and passing-away. The emphasis shifts from death to birth, from corruption to production, from nullification to creation. Time becomes henceforth the condition of significant achievement, the inexhaustible fountain of new wonders.

The great philosophers of evolution are one and all preoccupied in one way or another, with the creativity of time. Time brings forth what never was before and cannot be again. Less obstetrically expressed, time is precisely the process of coming-to-be, the incessant generation of novelty: there is nothing old under the sun. Time, creativity, novelty —these form the chord on which the mature philosophers of evolution composed their masterpieces. Darwin might perhaps have been surprised or even offended by some of their contentions, but he could hardly disclaim responsibility for a unique contribution to the climate in which their opinions flourished.

The three great contemporaries among the philosophers of evolution took hold of the new ideas each in his own way. Each brought them into relation with his primary philosophical interests. Each gave a characteristic expression to them. Among them, they exploited with genius most of the opportunities offered by the new ideas.

Creativity enters John Dewey's account in the form of "intelligence." It enters Bergson's metaphysics as the *élan vital.* Disguised as "emergence," it is of the essence of all evolutionary process, and thus it enters Alexander's cosmology as the basic fact. All three try to account for the possibility of novelty and its production in various modes, or at various levels of existence.

In his 1909 essay Dewey singled out the notion that species may originate in time as decisive for proper appreciation of Darwin's influence on philosophy. If species are not fixed, but come and go in time (it seemed plain to Dewey) most of the great philosophical tradition had to be rejected, or profoundly altered. This was, to his mind, a tradition in which the formal took precedence over the material, the rational over the empirical, the fixed over the fluent, essence over existence. To such a tradition the stark rigidities of formal logic were appropriate. But if species are not fixed, eternal forms or essences determining existence, then they are contingent forms determined by matters of fact, and logic must become radically empirical. Experience alone, not abstract ideas, provides knowledge, and experience grows with the interaction, the give and take, of the organism and its context of actual existence. Neither nature nor experience nor knowledge is static, unchangeable; none of them is final at any moment. The old logic of rational computation with abstractions must be set aside as vain and profitless. In its place must arise an "experimental logic," the logic of the evolution of experience and of ideas.

True to his Hegelian upbringing, Dewey never ceased to regard logic as integral to cosmic development—with, of course, a characteristic difference. Logic, or method, is simply the way in which experience naturally grows. Experience is not only *of* but *in* nature; the experiencer is no aloof spectator coolly observing all time and all existence, but a participant learning by interaction with nature; the knower is not a mind, but an organism with mental functions. Thus Dewey's logic takes more from Darwin than the abstract denial of fixed essences: it takes the whole view of man as a natural organism surviving by his wits.

An organism so considered is an integrated complex of functions in dynamic interrelation with environing events in nature. It must maintain itself ("itself" is its pattern of activities) with the help of nature; but also in the face of natural obstacles and threats of many kinds, since nature is impartial. The organism, in a word, can never cease its struggle to survive. If there are circumstances to which it cannot adapt itself or which it cannot modify to suit itself, the organism must disintegrate, die. For Dewey, being an organism is like riding a bicycle. If you stop moving, you fall off.

Also, if you try to ride pell-mell over every stone and pothole, you will be bumped off. The smart thing to do is to look ahead and take precautions, circumventing trouble or smoothing away obstacles. Such is the work of intelligence. Men are successful biologically because they have wits to live by. The fullest development, the product of a long experimental history, of this wit in practice is the method of deliberate experimentation in the face of difficulties, which characterizes modern science and technology.

Experiment methodically pursued, the central innovation and glory of modern science, has been called a "routine of discovery."[5] This routine had itself to be learned, or discovered, in the turmoil of trial and error. It is "natural" not as instinctive, but as successful in meeting natural conditions. It works; it turns nature against itself in our favor. But the key to its success, as Dewey never tired of emphasizing, is its inventiveness. The routine and repetitive, always doing the same thing in the same way regardless of circumstances, represented to him the epitome of stupidity. Habit is the paradigm of unintelligence. Intelligence, on the other hand, is always creative, alert to differences and original in response. Bare originality for its own sake never appealed to Dewey. What mattered was something effective in practice. Organisms exhibit intelligence by correcting their own mistakes. In this way intelligence is a natural product of evolution, since it promotes adaptation to environment by alertly avoiding old blunders while working out more successful ways of dealing with the moment-to-moment contingencies of life.

The foregoing rapid summary makes plain Dewey's orthodox Darwinism. Mind, from the evolutionary point of view, is not a substance independent, in the Cartesian manner, of the material substance of the physical world; it is instead a group of functions of a brainy organism, which promote survival and thus establish the ascendency of intelligent species, by natural selection. Like fur or fang, swiftness or ferocity, or the opposable thumb, mind (or brain in action) is an organ of survival.

Dewey did not re-think the notion of evolution. He took it over, virtually intact, from biological science and fitted it into a set of philosophical ideas from other sources. Prominent among these are logical ideas concerning experimental method, and moral, social ideas clothed in pragmatic trappings but rooted in his New England conscience. He despised above all things the hypocrisy of a merely theoretical morality that divided and frustrated men. He insisted on checking the moral claims of any conduct against actual results. No ideal, no motive can be so exalted that its fruits become irrelevant to its nature. Conduct, if it is good, will sweeten individual and social life, not by definition or by convention or by institutional (e.g., ecclesiastical) authority, but by its natural consequences in actual experience. The moral man, in Dewey's view, must always act intelligently—that is, creatively and with constant attention to actual results so as to correct mistakes in plans and policies. In this manner, Dewey combined evolutionism, pragmatism, and experimentalism in a coherent system of thought.

But, like Darwin before him, Dewey expanded the scope of evolution from biological life to the whole spiritual life of man. Darwin had done this almost absent-mindedly and not with philosophical thoroughness. Not so Dewey, who was at heart always a moral philosopher. He expanded the scope of "nature" until he all but burst the utmost restraints of specific meaning, although he never wavered in his intention to promote naturalism. But in pressing the concept of nature to the utmost, Dewey also exposed aspects of it that mechanism had never needed to stress. Nature's actuality is renewed from moment to moment, ever fertile, ever pregnant with novelties, ever promising unprecedented riches of experience to those who do not waver in intelligent search for the natural means to these new attainments of life. In his own way, Dewey belonged to the great tradition of philosophy: for him, while thought and being are not one and the same, experience and nature are. Imbedded in this is the new idea of time as fertility. Human experience is a natural part of the great adventure of nature. But "nature" is far from the physical world of Descartes, or even of Newton and Maxwell and Planck and Einstein. Dewey himself did not subject the quasi-mechanistic concept of evolution to the radical criticism which his mature outlook seems to require.

Radical criticism was the work of Bergson, of Alexander, and, later, of Whitehead. The most brilliant and most original critic of the Darwinian concept of evolution, Henri Bergson had published his most valuable works before Dewey wrote the essay on the influence of Darwin and years before he had completed the statement of his philosophy. Scintillating style reinforced the fascination of fresh ideas. But such brilliance may also have to pay a price. Excitement over some of Bergson's more daring suggestions now seems to have diverted attention for a while from the acuteness of his fundamental criticism. It was easier to question certain of his exaggerations than to take sober measure of his basic position.

With the economy of genius, Bergson summed up his original contribution in the title of his greatest work, *Creative Evolution.*[6] If evolution was to have distinctive meaning, Bergson saw it must express a feature of the universe that mechanism can not comprehend. He called this its creativity. Evolution implies that something really new comes into being; otherwise, we have nothing more than unexciting rearrangements of things in space. But if evolution is creative in essence, our scientific way of looking at nature must undergo drastic revision. We must modify our understanding of things and events both on the cosmic scale and on the scale of individual event.

Creativity in its cosmic dimension Bergson sometimes called the *élan vital*, "the surge of life." All life, for Bergson, expresses this ultimate creative principle. He does not consider life as the sum of living things; it is rather the surge of aspiration that differentiates itself in the myriad specific forms of particular life. Bergson sometimes writes of the surge of life as if it forms the source of all that is, both of life, which is at home in the intimacies of spiritual unity, and of matter, which is at home in the external relations of space. When the surge of life tires, relaxes its effort, then it degenerates, he suggests, into the inanimation of matter. Extension results from de-tension, loss of tension, the cessation of effort.

But Bergson also writes most commonly (for obvious reasons) of the surge of life as striving to make its way in a material world indifferent to the demands of life. Then it is that he may liken the surge of life to a torrent that splits itself as necessary to pass around obstacles or to seek out channels wherever they lie, until it fills every crack and crevice with its energies. The surge of life overcomes obstacles by a series of inventions, creative innovations, or discoveries, which differentiate it into the innumerable species that evolution has produced.

Bergson tries to show that the evolutionary record which the biologists of his generation accepted supported the creative conception of evolution rather than the Darwinian mechanistic evolution. For example, the constructing of virtually identical eyes from different embryonic materials by species belonging to wholly independent branches of evolution stretches the explanatory power of chance variations to the limits of improbability. Equally implausible in Darwinian terms are various cases, cited by Bergson, in which a favorable variation requires the previous occurrence and retention of another variation, which, however, itself performs no ascertainable function save to prepare for the arrival of the advantageous variation yet to come. We do not ourselves have to judge the truth of these examples in order to appreciate how conscientiously Bergson reckoned with the best available scientific knowledge. He sought to write for scientist as well as for philosopher, for he believed, on carefully examined grounds, that the mechanistic version of evolution simply failed in application.

Creative evolution is the antithesis of mechanism. Every form of mechanism assumes determinism. Every event has a necessary and sufficient cause—*ad infinitum*. This means, as Bergson correctly insisted, that "all is given"—everything is settled forever. But evolution requires novelty, else nothing has happened. The key to innovation is invention, creativity. The course of evolution cannot be pre-determined either by material or by final causes. The surge of life expresses its own inner need, but it does not move inexorably toward foreordained goals. It must endlessly discover the range of its possible satisfactions by inventing or devising new expressions of vitality.

On the cosmic scale, time assumes a new value. It is real where new achievements are being created. It is nullified by mechanism, which treats time as just another dimension of space. Mathematical models of events treat motion as a series of instantaneous positions, which might just as well coexist like a stack of snapshots. For Bergson this falsifies verifiable fact. It is useful for certain purposes, but as theory it runs counter to the simplest experience of motion, which is indivisible. I can move my hand from point *A* to point *B* in a single motion. If I should, instead, stop at some intervening point *C*, then it would take a new act, another motion, to go from *C* to *B*. A line *AB* can be divided into two segments *AC* and *BC*. The lines are static spatial figures. The motion *AC* is indivisable; it is temporal.

On the small scale, as well as on the cosmic scale, Bergson maintains the alliance of time and vitality, effort, creativity. At the most profound level of his criticism he recognizes that the problem of novelty forming the philosophical crux of evolutionism arises anew with the occurrence of each particular event—for example, each single motion. He takes the high line, not compromising with traditional habits of thought: there is motion but no *mobile*, no abiding substance that moves. The last drastic consequence of the notion of evolution is the denial of substance as something absolved of participation in the universal flux. The basic reality is event, process, motion. But motion here means the movement of life, the surge of life, self-renewing, profoundly imbued with ancient memories, striving now for nameless enrichment of the future.

With the sensitivity of a poet and the merciless criticism of a logician, Bergson stated, though he hardly solved, the problems evolution poses for philosophy: time, process, novelty, satisfaction.

Samuel Alexander's *Space, Time and Deity*[7] carried the philosophical elaboration of the idea of evolution to its logical conclusion in one direction, at least. Alexander shows no trace of interest in Bergson's impressionistic, almost romantic intuition of the surge of life. He could not, like Dewey, be content with evolution as simply one great scientific discovery having powerful implications concerning humanity. For Alexander, if evolution figured significantly in the world, it must be systematically involved in all that happens, and the way it is involved must be describable. In particular, the evolutionary principle should be observable at levels where nobody would ordinarily recognize the occurrence of life; it should, in a word, manifest itself physically as well as biologically, psychologically, and sociologically.

Like other evolutionists, Alexander—to echo his phrase—took time seriously, and the special way in which he did so defines the originality of his contribution. The essence of evolution he saw in the occurrence of novelty. Unlike Bergson before him and Whitehead after him, he did not deal intensively with the inescapable novelty of every actual occurrence. Evolutionary novelty for Alexander meant primarily a generalized "origin of species," the appearance of some absolutely new *kind* of actuality on the cosmic scene. To designate this concept of absolute innovation he borrowed the term "emergent evolution" from the British biologist Lloyd Morgan, to whose book by that title Alexander appropriately acknowledged owing much more than a convenient expression. The antithesis of emergent evolution is what we may call reductionist evolution, if it is entitled to share the name "evolution" at all. It assumes that the higher evolutionary stage could be, with sufficient knowledge, computed or otherwise derived from antecedent conditions involving only entities at a lower stage. According to the idea of emergent evolution, there comes a moment when a wholly new property emerges from a given complication of prior existents. The most familiar example of emergence is the appearance of life when certain physico-chemical conditions are satisfied; but Alexander finds many emergents in the evolution of the present state of the cosmos.

Another feature of "emergence" must be emphasized. The emergent, though irreducible to lower modes, yet depends upon the lower for its existence; on the other hand, the emergent determines its lower constituents to modes of behavior that they could not by themselves adopt. There is no life, for example, where there are no physico-chemical processes of organic physiology. But the animate body behaves in ways impossible to inanimate bodies. There is no conscious mentality apart from life; but mentality enables living bodies to behave in wholly new ways.

If we adopt Alexander's hypothesis that our cosmos has evolved by a series of emergent originations to its present intricacy and its subtlety of response, we must also follow his lead in back-tracking down the path of evolution to the most primitive conceivable origins. Space-Time is his name for the primordial basis of all existence. Time is as primitive as space; in fact, it could not be otherwise since each requires the other. Bare space and bare time, extreme abstractions from the real tissue of events, cannot actually exist. Descartes had identified physical nature with that which is spatial and left time a mystery referred to the continual creation of God; Bergson had treated the physicist's space as a fiction, a falsification of fact if not quite a fraud, whereas time expressed the creative surging of life; Alexander rescued elements of truth in both views by making use of ideas derived from relativity physics. He made the first thoroughly reasoned attempt to bring specifically physical events into intelligible relation with evolutionary process.

That is Alexander's importance to the present study. We need not consider how he attempts to show that the three dimensions of space require and are required by the three aspects of time (continuous duration in succession, irreversibility, betweenness); or how he traces the successive emergence of the sensible qualities, materiality, vitality, mentality, value, and the prospective emergence of a next higher but unknowable quality of "deity"; or how he constructs a realistic theory of categories as part of a thoroughly realistic epistemology. He presents us with the traditional hierarchy of space (-time), matter, life, mind, and God, but now translated from static into temporal terms, from structural into evolutionary metaphors. The relation of the emergent to that on which it supervenes is in many respects identical with the relation of form to proximate matter in Aristotle. It is hard for us today to read Aristotle's description of the various stages of life ("soul")—vegetable, sensient, rational—in his so-called *Psychology* without reading evolutionary ideas into it. It might be no less difficult for Aristotle to read Alexander without reading his doctrine of formal hierarchies into the evolutionary picture. But beneath the undeniable similarity of these views, they project hierarchies of drastically contrasting types. The Aristotelian has a fixed goal, luring matter to meet its requirements. For Alexander, the emergent is (on the surface, at least) an unaccountable, a strictly empirical by-product of a chance complication of simpler processes.

Space-time and Deity denote opposite ends of the evolutionary scale. But what entitles Alexander to the assumption that "later" means "higher," that the more complexly conditioned emergent is better than the less? What entitles Alexander to the assumption that evolution has an inevitably progressive tendency? How does he know that our aspiring after righteousness is not illusion? Perhaps there will be no next emergent—emergence is purely a matter of empirical fact, by definition incapable of rational anticipation. Perhaps the "deity" next emerging will turn out to be devilish.

In considering the course of evolution as the record of an upward trend in the cosmos, Alexander tacitly attributes an ambiguous role to "deity." The next higher stage can lure the effort of the lower only if somehow it enters already into the being of the lower stage. This suggests a bias in the universe, an implicit movement by "love," by need, desire, yearning, aspiration—in short, a God above and beyond the contingencies of the evolutionary process to underwrite a coming next emergent. Time must be taken seriously, yes; but it must also be seen in relation to significance beyond space-time. Evolutionary philosophy, we may summarize in conclusion, raised questions it did not answer. But they were fundamental questions which philosophers ought to take seriously.

III

Alfred North Whitehead read Bergson and learned from him, as he read and appreciated James and Dewey. He also refers to *Space, Time and Deity*, but he made little or no use of it. Actually, his mind owed more to the classical philosophers, particularly Plato and Locke, than to any of his philosophical contemporaries. The contemporary ideas that compelled his respect came from the technical precision and virtuosity of recent mathematics and symbolic logic and from the twentieth-century revolution in physics. But to speak of "influences" on Whitehead's thought diverts attention from the point of real importance: whatever he learned from others was transmuted by the alchemy of genius.

We have now entered upon the third and last stage of the philosophical adventures of the idea of evolution in the century since 1859. This is the stage of the eclipse of the idea as a powerful speculative tool. Whitehead belongs somewhat ambiguously to this stage. He has much more in common with the major philosophers of evolution than with the positivists (of whom he was unsparingly and unanswerably critical) or the existentialists, to whom the most recent years owe a new philosophical note. He was interested in the same kinds of problems as Dewey, Bergson, and Alexander were interested in, but with superior refinement of vision and coherence of construction and was unresponsive to sweeping negations by which positivists secured their narrow field of vision, and to equally sweeping though radically different negations by which the existentialists secured theirs. On the other hand, Whitehead makes no more than incidental and passing reference to the idea of evolution in his great constructive works. The notion of evolution which we find in Darwin and Dewey, or in Alexander or, indeed, in Bergson, contributed little or nothing to the finished architecture of his thought. Whitehead took little interest in the origin of species; more basic than that and required for its evolutionary interpretation is adequate insight into the origin of individual entities. His genius focused with blinding brilliance on the basic innovation of mature evolutionism, an innovation upon which all the men we have discussed have relied without subjecting all its aspects to thorough analysis. Whitehead's debt to evolutionary philosophy went deep, for he owed to it his most basic question: how can we interpret process as reality? Bergson had spoken of motion without a *mobile,* but he offered only a most impressionistic intuition of its nature. Dewey was often much closer to Whitehead because of his concentration on the passing adventures of actual situations; but, intent on other issues, he passed over the problems that absorbed Whitehead. With incomparable tenacity Whitehead wrestled with the problem of the coming-to-be of every individual event or "actual occasion," "actual entity," "occasion of experience."

All this carries us away from evolution as a constructive principle. That is how, in a most general sense, Whitehead contributed to the eclipse of evolutionary philosophy. His problem placed the central emphasis in a new place, and his systematic treatment of it reinforced this displacement. It is necessary to say a word about this in order to give substance to these very general interpretations; anybody acquainted with his works will know in advance that certain hints are all that a brief sketch can offer.

Whitehead's problem is not creative evolution but creative process, not emergent evolution of new qualities in the cosmos but emergence of new actuality each moment; not novelty of form or quality or species, but novelty of individual existence. Whitehead saw that creativity, though for him the ultimate cosmic principle, has its workshop, as it were, in individual actualities, or actual occasions. In the particular occasion, moreover, creativity is not absolute, but conditioned by relevant past actuality as a whole. The occasion owes the materials of its actuality to environing events that spread out to it in time, but it incorporates them into itself according to its own immanent self-constituting tendency, or "subjective aim," and thus realizes itself—achieves its little moment of creative actuality in a unique satisfaction. Thus it is that every entity comes to be.

Just as things that have happened, "the past," communicate themselves to the self-constituting present actuality, so each actual occasion in turn gives itself to the uses of future actuality. In this sense, though every finite actuality has its little moment of satisfaction and is no more, it never passes away into absolute nothingness as if it had never been. Every actuality enjoys what Whitehead calls "objective immortality." However insignificant an occasion may be, it makes just that insignificant but ineradicable actual difference to reality. An actual difference is one that nothing but an actuality can possibly make. It may be transformed by actual entities into which it subsequently enters or it may be ignored, resisted, rejected, but it cannot be made nothing.

Each individual occasion, event, or entity emerges uniquely from the past. It is a *new* actuality, an authentic emergent novelty. But Whitehead does not leave the notion of emergence, as Alexander did, on the level of unintelligible empirical fact that has to be accepted with "natural piety." For him, the process of coming-to-be involves the actual operation of both efficient and final causes. If achieved actuality did not transmit itself immediately to emerging actuality, then process would have nothing on which to work; on the other hand, if the entity in process of coming to be did not impose its own intrinsic tendency, or subjective aim, on the process by selecting some and rejecting other genuine alternatives available to it in a real future, then nothing would ever really happen, since then everything would already have been settled. Thus it is equally impossible to conceive of actual process without efficient causes and to conceive of it without final causes. Every actual entity is determined by the conditions of its origination, but it is also free in the realization of its own aim and the enjoyment of its own "satisfaction," or moment of indefeasible actual existence.

Whitehead's explicit adoption of final causes into his cosmology teaches one of the decisive lessons concerning the revolution in modern thought to which evolutionary ideas contributed. Evolutionism brought to philosophical attention the fertility of time, and it is in this way that it influenced philosophy most profoundly. It led to a radical revision of the mechanistic metaphor that defined the original bias of modern philosophy. Whitehead was fully aware of this change and stressed it by insisting on a philosophy of organism, rather than of mechanism. Bergson himself had demanded a changed outlook in his striking criticism of physical science, but he did not make plain the role of final causes in the creative unfolding of time. Whitehead did so, and thereby returned philosophy to classical models; his philosophy, the most independent and most up-to-date speculative effort of this century, belongs unmistakably to the Platonic tradition.

It remains only to suggest Whitehead's manner of meeting questions that Bergson, Alexander, and Dewey left in obscurity. In one way or another each had posed but not answered the problem of cosmic teleology. Bergson's surge of life is a frankly teleological creative principle. But in his anxiety to reject a universe in which everything was forever predetermined, whether by mechanical or by final causes, he left the teleology of the *élan vital* ambiguous and confused. The surge of life does not know in advance what it aims at—so be it! But if even matter is a by-product of life, then the surge of life must be wholly indifferent to what happens—one thing being as welcome as another—or else it must seek modes of actuality harmonious with its own intrinsic nature as life. Life seeks life, not non-life. But Bergson never clarifies this adequately. Alexander too, we saw, had a tacit teleology of emergence to which the radically empirical notion of *de facto* emergence scarcely entitles him. Dewey, for his part, always assumes that "nature" includes as real possibilities all the moments of genuine goodness that intelligent conduct can bring about. This means that nature provides for man's purposes. But in terms of his naturalism, this must remain for Dewey an article of unsupported faith.

Whitehead realized that a world of process, of true self-realizing activity, required a philosophical ground in an adequate theology. The details of Whitehead's theology, certainly in itself a topic worthy of painstaking examination, do not matter to the present study. It is enough to point out his conclusion that process can be understood as real only if it is conceived to be involved in an eternal ground. This is the aspect of God which he calls His "primordial nature," the immanent tendency of process, the bias in things that favors certain possible futures over others, the inalterable establishment of the abstract order of value or importance in the universe. It is by reference to this scale that developments may be "higher" or "lower" as well as simply later.

Whitehead does not intend this conception to imply the kind of inflexible determination of the world by final cause to which Bergson objected. His whole emphasis celebrates the freedom of each individual occasion to shape its own being—however crudely. The outcome of world-process is not foreordained; there is still genuine contingency in process—the future will be as it is made. Thus if God is not simply an abstraction or a remote and indifferent spectator (after the fashion of Plato's worst kind of atheism), He must have a constant concern for the adventures of free process. Thus God has His "consequent nature," in Whitehead's language. He needs the world, as the world needs Him. He allows it free activity and the time of real novelties, but redeems all the inevitable inadequacies of limited entities. Real time, in short, requires for its rational comprehension a thoroughly examined theology; but it is a theology as new as the conception of real time, if Whitehead understood it aright.

Whitehead does not hold forth expectations of inevitable progress to higher levels of realization. Evolution, in this sense, he leaves behind. He directs attention to questions at once more novel and more traditional than those of the major evolutionist philosophers. He deals profoundly with the most basic question raised by evolutionism, and by doing so transcends the provincialism inherent in an idea derived from a single scientific realm.

In 1929, when his Gifford Lectures, *The Quest for Certainty,* appeared, Dewey was already seventy years of age. Whitehead's major works were describing nature in a new way. Alexander's work was done. Bergson had published little for many years; and though a few years later he would again present a masterpiece to the world, *The Two Sources of Morality and Religion,* it would be his swan song—and that of evolutionism, too—as a creative factor in philosophical thought. Already Bertrand Russell's "scientific method in philosophy," his "logical analysis," had spread via Ludwig Wittgenstein's *Tractatus Logico-Philosophicus* (1920) to the European continent. There, in the late 'twenties and early 'thirties, this methodical tendency was converted into an uncompromising philosophy by Rudolph Carnap, Otto Neurath, Moritz Schlick, Hans Reichenbach, and other members of the "Vienna Circle." This view married traditional positivistic attitudes to the analytical techniques of symbolic logic and utterly rejected all "metaphysics," including, of course, evolutionism. This movement was joined by the indigenously English movement of philosophical or linguistic analysis, which owes much to G. E. Moore's "common-sense" approach, as well as to Wittgenstein's later teaching. Though they differ in important respects, we may for the sake of brevity treat them as allies in promoting analytic philosophy.

In exactly the same short span of years, another movement of thought on the Continent had suddenly gathered impressive momentum because of Martin Heidegger's work of genius, *Sein und Zeit* (1927). The title, ordinarily translated *Being and Time,* may be more pointedly rendered *Reality and Process,* to emphasize the coincidence of its publication at almost the same time as Whitehead's *Process and Reality* (1929); but two less similar works would be hard to imagine. *Sein und Zeit* served notice that the German vogue of Kierkegaard and Nietzsche in the miserable years following the shattering experience of the First World War had had profoundly important consequences. It was soon recognized that somewhat similar things were already being said by Karl Jaspers, who had come to philosophy through the practice of psychiatry, the effort to understand his patients having brought him to reflect on the inmost attitudes of every mind, beyond reach of reason and persuasion.

This "existentialist" movement took human life on its inside at the level of its deepest commitments. In so doing, it turned squarely against the whole pursuit of "objectivity" characteristic of the modern intellectual epoch. An evolutionary metaphysics becomes not merely false or even "meaningless" (as positivists might have said) but irrelevant. It has simply nothing to do with the continuing crisis which is the burden of life for each individual one of us.

In the English-speaking world, so many philosophers have worked at analysis of one kind or another that a recent popular paperback, purporting to offer a characteristic sample of twentieth-century philosophical writing, is called *The Age* *of Analysis.* A European, or even a Latin American, if he prepared a similar volume, might well name it *The Age of Existentialism.* It might include excerpts from Marcel and Sartre, from Heidegger, Jaspers, and Paul Tillich, from Martin Buber, from Nicolas Berdyaev, and from others. Only for the English-speaking among Western peoples has this way of approaching the reflective tasks of life had little appeal; though even here we must make an exception of theologians, many of whom have borrowed existentialist formulæ to express their religious intuitions.

These two movements, then, existential and analytical, have eclipsed older ways of doing metaphysics, one attacking from the subjective and the other from the objective side. Both have too much scope and variety even for the most cursory treatment in this paper; but it would be improper to close without indicating with more precision, though very briefly, the attitudes they take toward problems interesting to evolutionary philosophers.

In a variety of ways analytical philosophers have centered their interest on making clear what our languages, customary and contrived, mean. This activity tends to assume for them the whole identity of philosophical practice. Empirical questions belong to science, which offers the only tested methods of verification. Other seemingly empirical questions, including many traditionally discussed by learned philosophers, turn out, they say, to concern matters of linguistic usage or of logical syntax. In any case, questions of process, of novelty, of emergence, of creativity, of cosmic teleology are either handed over to natural science or are reduced to problems of usage, customary or technical. Philosophy in the grand manner—Bergson's, Alexander's, Dewey's, Whitehead's—is simply not attempted. Cosmology, evolutionary or not, may afford some subjective comfort to men's feelings but cannot make good any claim to rigorous critical objectivity.

Existentialism for its part does not simply look the other way in passing by traditional metaphysics. It transforms the central metaphysical question. Speaking largely with Heidegger in view, we may say that the time of his basic philosophical reflection is not the time of physics or of evolution, or even, quite, of Whitehead's process. It is the subjective time of the agony of decision, of dread of ultimate responsibility, of concern for finding something worthwhile to a temporal being lost in a wasteland of meaninglessness. Time for the existentialist connotes finitude, the crushing burden of temporality. His distress reaches its highest pitch in his awareness that as a being bound to time he is constantly giving himself actuality by inward affirmation of this or that alternative. He precariously holds on to his little moment of being by projecting himself into, or dangling himself over, the abyss of sheer nothingness, while the aid he needs and seeks withholds itself or turns away. This turning away, says Heidegger, is an occurrence in time—that is, a definite empirical event in human inward existence. Being is a creativity that yields the only possible answer to the question of questions: why is there something rather than nothing? We are ourselves beings, the plural pointing to our finitude. We in a way know, or at least surmise, Being or Reality, because we are ourselves beings and are real. But the point of the story escapes us. We know that we are *temporary,* as well as temporal beings: we shall die. Each day lights our path to dusty death. We did not choose to live; yet here we are, cast up on the shores of life, to make our way without signposts to—death. Why is there something rather than nothing? The point escapes us. Heidegger never, I think, ventures beyond this doubt; his self-appointed task is to bring home to others the true desperateness of the human situation. But his later writings hint perhaps at an answer like Job's. Certainly other existentialists hasten—much more eagerly—to the reassurance of a traditional theological conclusion.

Sketchy as this portrayal undeniably is, it will surely underscore enough the existentialist's total diversion of attention from objective questions of fact and cosmos. What am *I* doing here? is their problem, and they have no genuine interest whatever in what *here* is, and how it came to be as it is. The metaphysics of evolution is in full eclipse.

But must it so remain? When analysis and existentialism have mellowed and abandoned their exaggerations, will new appreciation of evolution be born?

That is a question for the next century, not for the years 1859-1959.

JAMES STREET FULTON

NOTES

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2. John Dewey, "Darwin's Influence on Philosophy," *Popular Scientific Monthly*, July, 1909, pp. 90-98; reprinted as "The Influence of Darwinism on Philosophy" in *The Influence of Darwin on Philosophy* (New York, 1910), pp. 1-19.
3. Andrew Dickson White, *A History of the Warfare of Science with Theology*, 2 vols. (New York, 1896). Evolution is discussed in Vol. I, ch. 1.
4. Francis Herbert Bradley, *Appearance and Reality*, 9th Impression (Oxford, 1955), p. 185.
5. Edward G. Ballard, "The Routine of Discovery," *Philosophy of Science*, XX, 2 (April, 1953).
6. Henri Bergson, *Évolution Créatrice* (Paris, 1907), trans. Arthur Miller (London, 1911).
7. Samuel Alexander, *Space, Time and Deity*, 2 vols. (London, 1920), being Gifford Lectures of 1916-1918.

EVOLUTION, TELEOLOGY, AND HISTORY

THIS essay is an inquiry into the correlation of some fundamental views of the world and ourselves in it. Our main concern will be to understand more clearly the meaning and the scope of evolution. But to this end we shall first try to distinguish the historical pattern of ideas from that of the physical sciences. Traditional terms like natural history and natural science indicate an awareness of some kinships but also of a basic difference in outlook which should be clarified. We ask: Does the world-view of physical science include any recognition of history in nature? The readily forthcoming negative answer would indicate the need of recognizing the historical and maybe yet other types of interpretation as essential to a comprehensive understanding of nature and human nature. And in such a more thorough world-view, we may then consider the range and the main direction of the evolutionary outlook.

A dominant tendency in modern thought has been the emphasis on a dynamic conception of nature as a system of processes. This idea has some old roots in classical antiquity, as is indicated by the varied connotation of the Greek word for nature, *physis*, from which we get our terms "physics," "physical." *Physis* meant origin or birth and growth, the source and process of activity in a thing, how it comes to be what it is, how it arises and realizes its character and constitution. The basic Greek question seems to have been: "How come?" When this active principle was regarded as the essential element, *physis* signified the primary stuff or matter, the substance or matrix of which things are made. *Physis* also came to connote the power of growth or vital agency in living things. Or else the essence of things was viewed in terms of their form and system, and then *physis* was considered as the cosmic order, and by extension the universe.

The Latin word *natura* had a similar flexibility of meaning. It was derived from the verb *nascor*, meaning "to be born." "The nature of things" signified their birth and original production, their heart and core, their essential substance and constitution. It came to mean the orderly source and course, the generation and pattern of things. In this brief verbal analysis the student of ancient thought may recognize hints of leading ideas in contending philosophical theories.

The emphasis on process is evident in the fundamental contemporary reconstruction of physics. In philosophy it may be noted in the ascendency of activism. Its kinship with an expansive evolutionary interpretation of all nature seems obvious: so obvious indeed as to call for some cautious reappraisal. Still more critically we should consider here the conclusion of some activists that the view of the world as process implies a basically historical perspective, a world-history. The growing importance of genetic methods of research, scientific explanation in terms of development, both of them have seemed to indicate a historical slant of thought. The South African philosopher, General Smuts, stated: "If activity is the essence of the universe, we see more easily why the universe is evolutionary and historical rather than static and unchangeable."[1] And John Dewey was even more explicit: "Aside from mathematics, all knowledge is historic; chemistry, geology, physiology, as well as anthropology and those human events to which, arrogantly, we usually restrict the title of history."[2] Hegel, on the other hand, rejected the appropriateness of the term "natural history." He declared roundly: "Nature has no history."[3] We have here two half-truths or two partial truths; the balance of emphasis, in our judgment, should incline towards Hegel's view. History, strictly considered, would seem to be concerned with distinctively human affairs. But this historical character, which is preëminently manifested in the careers of men and peoples, may also be regarded as a cosmic aspect which we can recognize in a measure, though far less relevantly or less significantly, in other fields of nature.

Keeping in mind the sharp divergence of judgment indicated above and our initial surmise by way of reconciliation, we should turn more carefully to our problem. Decisively characteristic of physical science is its view of the causal uniformity of nature. From this standpoint every type of process is to be regarded and explained as the necessary result of some variety of antecedent conditions. This system of uniformities is viewed as the general cosmic pattern. The detailed processes, to be sure, are in time, but the necessary connection which they exemplify are basic characteristics of the entire system across the time-span of specific occurrences. The book of nature, as read by physical science, has no distinctively historical pages, or we may say that its uniformities are all on one vast cosmic page. There is, to be sure, a history of physical science as a human activity and achievement; but is it conceivable that we could study the subject matter of physics or chemistry in any kind of historical order?

Thus we may say that physical nature, throughout numberless changes, manifests its basic and invariable uniformities. It does not reveal the progressive development and self-realization, or else the frustration, decline and fall, which are the marks of a historical perspective. In our day this view has been developed by Collingwood and also by the Spanish philosopher Ortega y Gasset. The so-called science of human nature, according to them, is a misconceived undertaking. It set out from the false presupposition that there is a certain entity called mind which is and remains there awaiting our analysis. But actually men and men's minds do not stay put, to be described and defined abstractly. Persons are ever in the process of achieving, developing, or misdirecting their character and significance. Their career must be studied in a biographical or historical view. Most emphatically Ortega y Gasset insists: "Man . . . has no nature; what he has is . . . history."[4] So the proper study of man is history, and we may say explicitly that the various humanities are chapters or branches of history.

This sharp separation of physical nature and human history calls for a cautious reconsideration, especially when we deal with the biological sciences. Is it altogether without significance that evolutionary ideas have been used so extensively in the various humanities: from the evolution of species to the evolution of social and economic institutions, evolution of language, of morals, of religion? Our attention may thus be directed to the essentially genetic and developmental character of evolutionary research, be it biological, anthropological, or explicitly humanistic. This aspect of evolutionism has been related to the basic outlook on reality as process. But is this outlook historical?

We should be on our guard here to avoid a confusion of fundamental ideas. Evolution may be interpreted in the specific Darwinian sense as the causally determined process of the survival of the fittest in the struggle for existence through fortuitous variations adaptable to specific environments. Or evolution may be used in the broader meaning of development, the unfolding of a process or a form of activity differing in kind under a variety of conditions. To be sure, there is a thought common to both of these uses of our term. The historian Bury called it "the *genetic* idea."[5] Darwin's epoch-making success in reconstructing biology on this genetic evolutionary basis inspired other workers to apply analogous methods to anthropological and humanistic research. This analogy of method has often been ambiguous. It has been guided by a due recognition of the essential differences between physical processes and historical activities. But it has also tended mistakenly to proceed from the acknowledgment of some quasi-historical aspects of the sequence of events in biological evolution, to the inference that human history can also be understood in strictly physical-biological terms.

The distinction here should not be drawn too sharply or rigidly, but neither should it be dismissed. The sound distinction should be one of emphasis. Historical studies may retain some elements of "naturalistic" method which is characteristic and dominant in physical science. Science in the form of "natural history" may entertain some aspects of the method which is more clearly and appropriately used in human history. We can understand both the correlation and the distinction between these two as our cosmic outlook proceeds from one of these perspectives to the other.

In making this last distinction we are, of course, clearly aware that we are comparing and also contrasting a necessarily abstract view of reality with one that aims at greater concreteness. From this standpoint it may be said that the abstract universality of the physical sciences cannot grasp fully the concrete reality which is portrayed in the historical perspective. The so-called natural history or history of nature is, as Croce put it, a "pseudo-history."[6] If I am to view anything in nature in a truly historical manner, I should have to cease regarding it as of a certain class or genus and should try to see it concretely in the way in which I would have to consider it if it were human. I might then proceed to study the biography, say, of a grizzly or of a glacier or a dust bowl, but as it came to manifest historical portraiture it would tend to lose scientific analysis and definition. The strict scientist might even suspect such accounts as "nature-faking." On the other hand, we should not overlook the opposite procedure, in which the concrete actuality of ongoing human life has been forced, with what may be called "history-faking," into the abstract framework of materialistic determinism.

This distinction, between scientific explanation and historical portraiture, points to a basic issue of philosophical interpretation. It is the issue between mechanism and teleology. It is accentuated in biology even more than in the other physical sciences; or better, the fundamental account of biological processes emphasizes the issue in a distinctive way which is decisive.

Physics and chemistry in their own fields and perspectives proceed on a definitely mechanistic basis. It would be only confusing to import teleological reasoning into astronomy or geology. Modern physical science has made its great advances precisely because it has recognized and respected its own appropriate postulates. Our problem here arises when we turn from strict physics to a more integral view of nature and human nature. The commitment to mechanistic categories, which is essential to the effective physical account of nature, misses somehow the characteristic interpretation of human lives. Valid in its own field and on its own postulates, physical science seems to indicate the need of other significant views of nature, if we are to understand ourselves and our own scientific activities as well as the physical system of the world with which we are dealing. So we may say that while the principle of teleology is not required, is indeed excluded, in physical science itself, it is raised as a problem by physical science in its relation to an ultimate philosophical interpretation of reality.

The role of teleological reasoning in biology seems to be a different one, but about this alleged difference there has been a radical controversy in evolutionary theory. We should appraise this disputed evolutionary teleology by considering some of the contending views about it.

One side of the argument is the strictly mechanistic interpretation of evolution. The materialistic evolutionist judges that Darwin's principal systematic achievement was his integration of biology with the other physical sciences, his exclusion of Providential or any other kind of design as a biological explanatory principle. According to this view, the fuller development of evolutionary biology must be only along these mechanistic lines. Thus Ernst Haeckel advocated explicitly a "dysteleological" method. Against any appeal to design in biological theory or against any interpretation of adaptation or fitness as in any sense purposive, he demanded insistently a mechanistic explanation analogous to that in physics and chemistry.

The mechanistic evolutionist has dismissed the traditional doctrine of design both by outright rejection and by citation of negative evidence. One type of evidence for "dysteleology" or purposelessness is that of rudimentary or vestigial organs. How can a teleological biology explain the vermiform appendix in the human intestinal system? In our herbivorous ancestors it was much larger and of great digestive use. In us it is an evolutionary survival, useless and often injurious. The comparative anatomist can undestand its persistence, if he adheres to his mechanistic view of zoological evolution. On a teleological plan, however, it is only perplexing. In a theological version of a design in nature, it would cast reflection either on the goodness or on the good sense of Divine Providence.

This sort of strictly mechanistic rejection of purposive adaptation in any form has been criticized as failing to do justice to many facts in biological evolution. Some of these objections seem fundamental. Without reverting to the traditional doctrine of Providential design in nature, some biologists have found it necessary to include in their evolutionary theories the recognition of teleology in some form. A consideration of some of the more important alternatives to a rigidly mechanistic biology may outline the wide range of basic thinking in the evolutionary field. I shall be brief because the major theories have been examined with great care by my colleague in this symposium, Professor Fulton.

In the history of ideas, Vitalism in some form has always expressed the insistence that living beings manifest something unique and fundamentally different from anything in the fields of physics and chemistry. To understand living behavior we must recognize some special directive power in every organism. This trend of speculation connects the names of Erigena, Paracelsus, Stahl, Schopenhauer. The unique teleological factor has been called by various names: vital principle, vital force, or as Hans Driesch, a chief modern advocate of the theory, phrases it, borrowing his term from Aristotle, "entelechy." The modern vitalist rejects any mechanistic reductionism in biology. Unlike physical or chemical process, organic behavior and evolution manifest a certain autonomy of character, a unique principle of adaptation for self-maintenance. The observable facts of organic regeneration indicate an integral capacity of the organism to act determinately as a whole on any of its specific parts. This mutuality of the whole and its parts is inexplicable on any rigidly mechanistic theory.

This doctrine has, of course, met strong rebuffs from the mechanists, but it has also been severely criticized by thinkers who question or who reject strict materialism. Instead of postulating a special "vital force" to explain biological processes, should we not rather study the behavior of living beings, recognizing both the features which are shared with physical and chemical reactions, and also the peculiar and distinctive biological characteristics? Among the latter, special attention has been called to self-repair and restoration, to the related biological principle of maintenance of normality, and to the factors of integration and coördinated behavior. Vitalism has been criticized for its proposed cleavage between organic and inorganic nature. Why maintain such a radical discontinuity? Why may it not be that the physico-chemical substances and processes, under certain so-called organic conditions, become the matrix for the manifestation of new properties and new forms of behavior?

This latter alternative view is expressed in the theory of Emergent Evolution, advocated by the biologist Lloyd Morgan and expanded with systematic mastery in the cosmology of Samuel Alexander. Alexander's statement may be cited: "New orders of finites come into existence in Time. . . . New complexity of motions come into existence, a new quality emerges. . . ."[7] The primary groundwork of existence, which Alexander calls Space-Time, operates in a system of causal mechanism familiar to us in the physical sciences. But under certain conditions it becomes the matrix for a radically new order and quality of being which we call Life. And just as

Life thus unpredictably yet unmistakably emerges out of Space-Time, so Mind emerges out of Life, intelligence out of organic-biological behavior.

In considering the relation of the lower or matrix to the higher or emergent character, we are warned to avoid a twofold error. We should not, like the materialists, reduce the higher to the lower and interpret life and mind as simply more complex mechanisms. Nor should we, like so many idealists, overemphasize the higher quality and regard physical existence as essentially a latent form of spirit. At every level of existence we should do justice to the facts: recognize that level for what it is, but also see it as the emergent from lower levels and likewise as the matrix of a higher realization. The theory of emergent evolution would avoid oversimplification of nature or reductionism in any direction. It would recognize the complexity of existence with its three main stages, physical mechanism, life, and mind. And it would not rigidly assign limits to the process of emergence, for Mind already indicates a boundless upward reach of spiritual character. All along this dynamic range the higher quality is nowise a mere resultant or a predictable effect. It is in each case an instance of genuine upsurge in nature. And this fundamental character of emergence, outstandingly evident in the uprise of Life and of Mind, is manifested all along the line. Thus the emergence of consciousness covers a widespread gradation of processes, from the most rudimentary behavior of low organisms to the most complex intelligence in man.

In his theory of emergence Alexander viewed the entire cosmic span, from Space-Time to Deity. He regarded evolution as the natural history of values. "Darwinism is sometimes thought to be indifferent to values. It is in fact the history of how values come into existence in the world of life. . . . The doctrine of natural selection explains not how types are generated but how they come to have value."[8] The arrow of dynamic reality at the level of spiritual activity points to an ever higher summit. We cannot assign any limits to creative intelligence. This ever higher emergent quality is what Alexander means by "Deity." We cannot define it, and we cannot say that it exists, but by its very character it is ever potential, the infinite Divine Beyond.

An equally radical alternative to mechanistic biology is Henri Bergson's theory of Creative Evolution. The adjective in this term is intended to characterize not only evolution but reality altogether. Bergson criticizes the sciences and the philosophies of the past for their failure to give due recognition to the integral ongoing current of existence. In theory of knowledge he seeks to expose the inadequacy of intellectual construction with its schematic procedure. He objects to the misinterpretation of real time, duration, as a succession of discrete extents or moments. He criticizes the misleading view of the course of existence as a series of events. Against both the mechanistic outlook on nature as predetermined in every detail and the eternally planned teleology of Providential design, he champions the recognition of really creative consciousness and the living stream of reality.

Bergson maintains activism in cosmology without any reservation. "There are no things, there are only actions."[9] The cosmic agency, all-pervading in every living process, is the creative flood itself, the vital urge manifested throughour nature. He called it the *élan vital.* But it should be stated clearly that Bergson's insistence on the unpredictable creativity of living processes does not exclude absolutely the use of causal explanation in biology: not absolutely. Our abstract mechanism, which serves us well enough perhaps, though imperfectly, in physics and chemistry, has its part in biology also. But in biology its part is nowise the chief role. The chief role, the dynamic principle in evolution, is the *élan vital.* Immersed in matter, it spurts out in ever new currents. We can regard plant and animal life as the two main directions of its outpouring, two ways of accumulating energy and then letting it flow into flexible channels. All the way through, we should emphasize the vital urge; we should get into the evolutionary flux itself, not reduce it to stages which we then artificially try to recompose.

The more directly we observe ourselves, the more clearly we see that we never stay put as mere discrete entities, but on the contrary are continually in a process of achieving ourselves. In the perspective of creative evolution we have no abstract universal character that can be analyzed and formulated. We require a historical account: not explanation but portraiture. What is so evidently true of ourselves is true, in different degrees, also of lower forms of life in the stream of evolution. Evolving life manifests the origins and growth of new lives. The study of it is concerned primarily with genesis rather than with the repeated uniformities with which so much of abstract physical science deals. So Bergson finds evolutionary inquiries enlightened by the subordination of the traditionally scientific to a creative-historical perspective.[10]

Even those who would not go the whole length with Bergson or with Lloyd Morgan and Alexander or with Driesch have felt bound to admit the inadequacy of a rigidly mechanistic biology. Surely the evolutionist cannot use the principle of adaptation without acknowledging its ultimate teleological implications. So T. H. Morgan concluded that "the adaptations of organisms are something peculiar to living things, and their obvious purpose is to maintain the integrity of the individual or that of the species to which the individual belongs."[11] Against the mechanist's claim to Darwinian leadership, it has been maintained by J. B. S. Haldane that "the theory of natural selection does not constitute the smallest step in the direction of a mechanistic conception of life." Variation and hereditary transmission cannot be understood rightly if we regard them as mere physico-chemical effects of the environment on the plant or animal. The living organism manifests some sort of purposive agency and initiative. "Heritable variation must be regarded as a fresh striking out of life."[12]

The critics of a rigidly mechanistic theory in biology have cited a mass of evidence indicating purposive or quasi-purposive behavior, not only among mammals and birds but also at lower levels, especially among insects. The elaborate organization of insect life, in ant hills or beehives, has seemed to point beyond a strictly mechanistic explanation. Not only the functional explanations of behavior but also the structural variation of organs adapted to definite conditions in the environment appears perplexing to a strictly physico-chemical theory of evolution. Critics have pointed out that the organism seems to proceed on some sort of a self-preserving, self-promoting plan, with an initiative in variation and integration. Especially in the attainment of certain complex structures, as for instance in the evolution of the eye, there are cases where a great number of different and very delicate adjustments have to be realized before the organ can function advantageously at all. The explanation of the survival and propagation of the many initial details of such a structure on a factual mechanistic basis seems to strain belief.

On the higher levels of animal life the evidence of dimly manifested and then more and more definite approaches to some form of mental activity raises further difficulties for the mechanist. Darwin realized that the evolutionary explanation of mental powers and the moral sense was a requisite part of his theory, and he treated these problems, with his characteristic candor and caution, in *The Descent of Man.* His work in this field stimulated his followers to important extensive studies of the evolution of mind. Distinguished works in this field are Edward Westermarck's *Origin and Development of the Moral Ideas,* L. T. Hobhouse's *Morals in Evolution,* and Alexander Sutherland's *Origin and Growth of the Moral Instinct.* Westermarck and Hobhouse center their attention on the historical evolution of morals in human life from the earliest primitive societies. Sutherland endeavors to follow Darwin further in tracing the first beginnings or antecedents of moral activity in the instincts and reactions of animal behavior. The specific theoretical explanations advanced by these and other investigators may vary in details or in some major principles, but they all share the evolutionary outlook.

We are told that in the far-flowing stream of life, organisms develop increasingly complex cerebro-neural systems capable of conscious reactions, and then of mental response, moral behavior, understanding, and judgment of values. Animal gregariousness and the herd instinct develop into human social-mindedness; the urge for fighting back and for retaliation grows into a sense of retribution, with the recognition of justice and punitive law in prospect; the parental instinct and group solidarity mature into conscious sympathy and benevolence; the effective restraint of offending members and the corresponding individual sense of group compulsion ripen into a consciousness of moral obligation, duty, and conscience. The regard for the preservation of the herd and flock grows and may gain precedence over the concern for individual survival. In these and other ways, the preface and the first chapters of evolutionary morals have been traced by Darwin and his successors.

In a broader survey, not limited to moral behavior and not always viewed in evolutionistic perspectives, the beginnings of mental reactions in the life of the higher animals have likewise been made the subject of many detailed investigations. It may suffice here to mention one outstanding example of this type of inquiry, Wolfgang Köhler's work, *The Mentality of Apes.* Köhler noted that the brain structure and the bodily chemistry of the higher apes show greater similarity to those of human organisms than to those of the lower apes. He studied with especial care the behavior of some chimpanzees which seemed in many ways like human responses, and he raised the question whether the apes may not show intelligence analogous to ours. If this question is answered affirmatively, we may be in a position to recognize in the first or primitive instances of animal intelligence some of the characteristic factors in the evolution of mind.

Köhler does not proceed to dogmatic conclusions, but his researches indicate several lines of evidence for what may fairly be called a definite trend towards mentality in the behavior of the higher apes. The chimpanzees which he observed were capable of using roundabout methods of catching their objects. They showed some grasp of what the total situation required. They used strings or sticks or other implements to pull or push the food in the desired box or bag hanging or swinging out of their unaided reach. They would scratch a stone from the ground and throw it after an animal which they might be chasing; or, unable to move a heavy box on which they had to climb in order to grab the food suspended above their heads, they would first take out the stones that had been packed in it. They would join two sticks to lengthen their pole to the needed length, or pile up one box on top of another—four of them on one occasion—to gain the required height. This work was done sometimes in collaboration. They showed capacity for planning with foresight and with some control of very strong appetite. On their being driven from their stockade to their sleeping pens in the evening, they had to cross a spot covered with lush green weeds of which they were very fond. At first they all stormed upon their juicy fodder, but when the keeper drove them insistently towards their pens, one of the chimpanzees would suddenly stop eating and begin hastily to tear up the weeds and so would carry a tremendous bundle of them to his den.[13]

While some of these researches have been pursued without any explicitly evolutionistic purpose, they all have bearing on evolutionary theory. One interpretation of them has been to regard so-called mental behavior as the factual effect of biological reactions. But even on a basically mechanistic view of biological processes, this account must still recognize clearly the eventual attainment of mind. How is this recognition to be understood? Either we should adhere rigidly to the exclusively mechanistic perspective, in which case we miss the fundamental characteristics of mind. Or we may acknowledge the distinctive character of mental activity, of thought and understanding and purposive conduct and moral judgment. In that case we should discern in the evolutionary course the attainment of non-mechanical activities, teleological and rational. We should then require a reinterpretation of the evolutionary process, to account for this attainment; we should have to expand or supplement the evolutionary perspective by other views of nature and of human character.

The former, mechanistic explanation of the origin and development of mind, as gradually evolved from organic reactions and manifesting only physical and physiological properties, would claim the merit of undeviating naturalism in its explicit rejection of teleology in any form, admitting only purposeless behavior, determined mechanically. But then consistently it could not recognize genuinely purposive activity or pursuit of values anywhere, even at our human level. This view suffers from the essential defect of rigid materialism, for it cannot account for itself as a theory or for its claims to truth and validity. Reason cannot thus reason itself out of existence.

If we appraise the second view, which begins by an unambiguous recognition of mind and its various forms of intelligent activity, the further inferences from it are very significant. The first one—a revision of evolutionary doctrine to include the clear explanation of mind—is illustrated in the theories of creative evolution and emergent evolution. Secondly, these two theories in their respective ways may proceed to a more expansive cosmic outlook on nature and on human character, from a number of significant approaches. Reality is complex, and nature is not to be exhausted in any one abstract formula. The physical sciences express in their postulates a view of the cosmic mechanism, and their formulations of the structure and laws of nature have fully justified their mechanistic perspective. Evolutionary biology has shown its merits in appropriating to its use, as much as suitable, the physico-chemical outlook on nature. This principle in biological method was defended with balanced judgment even before Darwin's work by the great physiologist Johannes Müller: "Though there appears to be something in the phenomena of living beings which cannot be explained in ordinary mechanical, physical, or chemical laws, much may be so explained, and we may without fear push these explanations as far as we can, so long as we keep to the solid ground of observation and experiment."[14] The last clause here is important in guiding sound fundamental theory in biology. Its distinctive problem, the understanding of living processes in their evolution, especially at its higher stages, has confronted the systematic evolutionist with the need of understanding the origin or the emergence of mind and of accounting for the boundless development of intelligence and of the values with which human beings have been characteristically identified. Evolutionary biology, rightly allied as it is on the one hand with the physical sciences and indeed having its basis in them, seems to open new vistas on reality, human and social perspectives to which no rigid mechanistic formulas can do justice.

These new vistas and the problems which they raise are shown in the expansion of evolutionary ideas in the various fields of the humanities. The basic idea of evolution, the principle of development as a cosmic category, has proved fruitful in many humanistic inquiries. All of us know the productive work which has been done in the evolution of social and economic institutions, the evolution of language, of art, of religion. We have just been considering briefly the investigation of the evolution of morals from the earliest primitive societies, or earlier still, from the higher animals. The title of a notable treatise by Edward Caird comes to mind: *The Evolution of Theology in the Greek Philosophers.*

The examination of this varied material or even a cursory glance over the bibliographies in these respective fields would show the fruitful expansion of the humanistic outlook by the application of the evolutionary principle. Our insight into any human activity is clarified and deepened as we come to understand its gradual development. The genesis of ideas, practices, and institutions has some of its roots in physiological reactions to conditions in the environment. Searching inquiries in these fields indicate man's groping and then more definite advance from organic drives to intelligent purposes. We may trace the growth of the human animal to fuller rational stature. And we may thus perceive that even at his full maturity man never quite surmounts his animal rootage. He is ever illustrating the truth of Aristotle's definition of him as a rational animal. In his most primitive state he is not altogether a beast, and at his highest levels of civilized existence he is never purely rational. He needs the two perspectives, related, to manifest his full nature.

All these inquiries may be described as studies in the evolution of values. And values are characteristically expressed in contending interplay. Their progressive emergence and development manifest what we may call the twofold, Janus-like outlook of the basic principle of evolution as it is applied to the various humanities. The development of social and economic processes and institutions is obviously bound up with climate, food-supply, and other environmental conditions, as well as with human demands and ideals. Language has its organic medium as well as its almost boundless range of intellectual and poetic expression. The arts have yielded the high achievements of creative genius, but music has its physical and physiological aspects, and such a book-title as *Anatomy for Art-Students* needs no further explanation. All along the line, evolution in the humanities has been a dual manifestation of the complexity of human nature, emphasizing the need for a philosophy of perspectives, to do justice to the many fundamental aspects of reality.

By way of closing summary, we may state that evolutionary biology, in one direction, has been marked by a thoroughly justified account of living processes in factual-mechanistic terms. But the further evolutionary insight has opened up another perspective of the genetic principle of development. Animal behavior that at its rudimentary beginnings seems to be only very complicated chemistry, manifests increasingly at its higher levels a teleological tendency, and then unambiguously purposive and intelligent activity. The evolutionary biologist was bound to include man in his zoological museum, but the course of evolution in human life could not be understood fully in the earlier terms, as survival or extinction by fortuitously fit or unfit adaptations to certain environments, as a mere mechanics of behavior.

The genetic process at human levels is a process increasingly directed by intelligence, a process of purposive activity, of choice between contending values, of achieving not only organic but also spiritual integration and fulfillment. This sort of genetic process is not a mere series of events but a significant career, which we commonly call history. The principle of evolution as used in the various humanities manifests characteristically this historical aspect.

RADOSLAV A. TSANOFF

NOTES

1. *Holism and Evolution,* p. 337.
2. *Experience and Nature* (1925), p. 163.
3. Cf. R. G. Collingwood, *The Idea of History* (1946), p. 114.
4. Cf. *Philosophy and History,* Cassirer volume, ed. Raymond Klibansky and H. J. Paton (1936), p. 313.
5. *Selected Essays,* p. 23.
6. *On History,* trans. Douglas Ainslie (1921), p. 135.
7. *Space, Time and Deity* (1920), II, 45.
8. *Ibid.,* II, 309. Cf. also *Philosophical and Literary Pieces* (1939), p. 286.
9. *Creative Evolution,* trans. Arthur Mitchell (1922), p. 261.
10. *Ibid.,* pp. 7, 9, 31, 38 f.
11. *Evolution and Adaptation* (1908), p. 29.
12. *The Philosophical Basis of Biology* (1931), pp. 21, 20.
13. Wolfgang Köhler, *The Mentality of Apes,* trans. Ella Winter (1948), pp. 11 ff., 25 ff., 101, 119 f., 128 f., 167 ff., 276.
14. Cf. *Progress and History,* ed. F. S. Marvin (1921), p. 262.

THE SUPERNATURAL NATURALISM OF DREISER'S NOVELS

THE first chapter of *The Financier* includes a passage commonly identified as the epitome of Theodore Dreiser's naturalism. Frank Cowperwood, an intelligent schoolboy filled with curiosity about the world, having rejected the story of Adam and Eve, prefers to learn about life from a tank of sea specimens in front of a fish-market. There, day by day, he watches the losing life-and-death struggle of a squid against a devouring lobster.

> "That's the way it has to be, I guess," he commented to himself. "That squid wasn't quick enough." He figured it out. (p. 4)

This dramatic event in Cowperwood's childhood obviously is an important clue to his adult attitudes and behavior: the observed ruthlessness of nature sets a compass to his personal unscrupulousness—

> Lobsters lived on squids and other things. What lived on lobsters? Men, of course! Sure, that was it! And What lived on men? he asked himself. Was it other men? . . . He wasn't so sure about men living on men; but men did kill each other. . . . Sure, men lived on men. Look at the slaves. They were men. (*ibid.*, p. 5)

The lifetime motto of Frank Cowperwood, "I satisfy myself," is not, however, a master key to unlock the total meaning of even his story, far less of the Dreiser novels in general. The epilogue of *The Financier* opens with a kind of meditative essay likewise drawn from sea life:

> There is a certain fish, the scientific name of which is Mycteroperca Bonaci, its common name Black Grouper, which is of considerable value as an afterthought . . . That very subtle thing which we call the creative power, and which we endow with the spirit of the beatitudes, is supposed

> to build this mortal life in such fashion that only honesty and virtue shall prevail. Witness, then, the significant manner in which it has fashioned the black grouper. . . .
>
> Mycteroperca moving in its dark world of green waters is as fine an illustration of the constructive genius of nature, which is not beatific, as any which the mind of man may discover. Its great superiority lies in an almost unbelievable power of simulation . . . You cannot look at it long without feeling that you are witnessing something spectral and unnatural, so brilliant is its power to deceive. . . .
>
> What would you say was the intention of the overruling, intelligent, constructive force which gives to Mycteroperca this ability? To fit it to be truthful? To permit it to present an unvarying appearance which all honest life-seeking fish may know? Or would you say that subtlety, chicanery, trickery, were here at work? An implement of illusion one might readily suspect it to be, a living lie, a creature whose business it is to appear what it is not, to simulate that with which it has nothing in common, to get its living by great subtlety, the power of its enemies to forefend against which is little. The indictment is fair.
>
> Would you say, in the face of this, that a beatific, beneficent creative, overruling power never wills that which is either tricky or deceptive? Or would you say that this material seeming in which we dwell is itself an illusion? If not, whence then the Ten Commandments and the illusion of Justice? Why were the Beatitudes dreamed of and how do they avail? (pp. 501-502)

This passage offers one of the most useful guides to Dreiser's curiously supernatural naturalism,[1] and thereby to his conception of evolution. Like many or most of the creative writers of the preceding half or three-quarters century, he takes for granted a teleological, vitalistic explanation of the evolutionary process, but he forges his special interpretations upon the anvil of his own mind. For Tennyson, the horror of "Nature, red in tooth and claw" is compensated by the promise of immortality for the individual, and for the race by the vision of an era "a hunded thousand, a million summers away" when men shall "lay/The Ghost of the Brute that is walking and haunting us yet."[2] Browning agrees that

Nearer we hold of God
Who gives, than of His tribes that take, I must believe.
. . . .
A brute I might have been, but would not sink i' the scale.
("Rabbi Ben Ezra," ll. 29-30, 42)

To George Meredith, a philosophical view of the orderly march of the stars affords both a resolution of the problem of evil ("Lucifer in Starlight") and an awareness of the evolutionary unity of a universe interpenetrated by divinity:

The spirit leaps alight,
Doubts not in them is he,
The binder of his sheaves, the same, the right;
. . . .
That there with toil Life climbs the selfsame Tree,
Whose roots enrichment have from ripeness dropped.
So may we read and little find them cold;
Let it but be the lord of Mind to guide
Our eyes . . .
("Meditation under Stars," 11. 50-52, 57-61)

Theodore Dreiser is too good a Spencerian not to differentiate between Appearances and Actuality, but by the same token he is too much a Huxleyan agnostic to share the optimistic predisposition of Meredith, Browning, and Tennyson. In effect, they beg the question that is central to his investigation of the nature of things, for they not only posit a spiritual basis of ultimate reality, but also assume by faith an essential harmony with man's highest ethical nature. For Dreiser, the question of "the intention of the overruling, intelligent, constructive force" remains an eternal riddle. On the evidence of Appearances, the creative power seems to be "subtle, cruel, crafty, and malicious"; or, at best, "a dual personality or a compound of good and evil—the most ideal and ascetic good, as well as the most fantastic and swinish evil . . . a God of storms and horrors as well as of serenities and perfections" (*The "Genius,"* pp. 694, 726). Nevertheless, to interpret Dreiser's novels as an elaborately documented rejection of "the spirit of the beatitudes" would be the greatest possible error. His life work, to be sure, was an inquiry into overwhelming outward evidence that "the constructive genius of nature . . . is not beatific," and in Cowperwood he drew the portrait of a materialist who built his career upon that judgment. But Theodore Dreiser, far more closely akin to Eugene Witla than to Frank Cowperwood, never loses sight of a radically different, yet equally tenable, interpretation of the same evidence: "that this material seeming in which we dwell is itself an illusion." Undoubtedly thinking of himself, Dreiser describes Witla as "introspective, imaginative, psychical" (*ibid.,* p. 694). Although Eugene oscillates between views of the universe as an expression of evil, of good, and of mixed good and evil, until he finally reaches a dead-center of uncertainty, at his nadir of spiritual distress he is cheered to learn from his reading that evolutionary theory does not "shut out a conception of a ruling, ordaining Divinity." A writer on biology explains the cellular basis of life as "God's instrument and mediator in materiality"; a physicist, describing the world newly revealed by the ultramicroscope, concludes that "every motion is controlled by mind. . . . This micro-universe is rooted and grounded in a mental base." (*Ibid.,* pp. 696-697.) More especially, an article by Alfred Russel Wallace interests Eugene Witla "as a proof that there might be, as Jesus said and Mrs. Eddy contended, a Divine Mind or central thought in which there was no evil intent, but only good" (*ibid.,* p. 697), and thus bears most directly upon the focal Witla-Dreiser problem of the moral quality of the universe. Because it is quoted in the novel at considerable length and with evident approval, the article is an important index to Dreiser's own evolutionary thinking.

> "It is very necessary to presuppose some vast intelligence, some pervading spirit, to explain the guidance of the lower forces in accordance with the preordained system of evolution we see prevailing. Nothing less will do. . . .
>
> "If, however, we go as far as this, we must go further. . . . We have a perfect right, on logical and scientific grounds, to see in all the infinitely varied products of the animal and vegetable kingdoms, which we alone can make use of, a preparation for ourselves, to assist in our mental development, and to fit us for a progressively higher state of existence as spiritual beings." (*ibid.*, p. 698)

A difficulty with the term "Darwinism," in any context, is that even Charles Darwin was not a perfect Darwinite. As is well known, he harmonized his authorship of *The Origin of Species* with Christian orthodoxy, and could "see no good reasons why the views given in this volume should shock the religious feelings of any one" (Ch. XV: "Recapitulation and Conclusion"). It is perhaps not so often remarked that, much in the same spirit, he sought to reconcile his theory of natural selection with certain older principles of Lamarckism; indeed, he sharply protested against a "steady misrepresentation" to the effect "that I attribute the modification of species exclusively to natural selection" (*loc. cit.*)—so that with some plausibility Lysenkoism has been known as "Darwinism" in Russia. If A. R. Wallace, fifty years after he had helped Charles Darwin to set the doctrine of evolution upon a firmly naturalistic base, could reinterpret it in mystical-teleological terms, it is not surprising to find Theodore Dreiser's fictive naturalism often strikingly un-"Darwinian."

Another severe difficulty is that the first generation of Darwinists, both biological and literary, lacked a sound theory of inheritance. Conceivably, had Theodore Dreiser been more alert to the twentieth-century developments of Mendelian genetics, he might have advanced significantly beyond the imaginative, intuitive determinism of Zola and

Strindberg; but actually his conception of heredity, far from being scientifically rigorous, scarcely rises above the level of folklore and family gossip. For instance, Frank Cowperwood questions the potentialities of the Negro for development under freedom: "He had observed that race from his boyhood with considerable interest, and had been struck with virtues and defects which seemed inherent and which plainly, to him, conditioned their experiences." (*The Financier*, p. 85.) Jennie Gerhardt "was a product of the fancy, the feeling, the innate affection of the untutored but poetic mind of her mother combined with the gravity and poise which were characteristic of her father" (*Jennie Gerhardt*, p. 1). Of the father, in turn, Dreiser reports:

> [H]is honesty, like his religious convictions, was wholly due to inheritance. He had never reasoned about it. Father and grandfather before him were sturdy German artisans, who had never cheated anybody out of a dollar, and this honesty of intention came into his veins undiminished.
> (*ibid.*, p. 54)

Eugene Witla is significantly attracted to his future father-in-law:

> Eugene was drawn to old Jotham as a filing to a magnet. His was just the type of mind that appealed to him, and Angela gained by the radiated glory of her father. If he was so wonderful she must be something above the average of womanhood. Such a man could not help but produce exceptional children. (*The "Genius,"* p. 179)

The close physical resemblance of the first cousins, Clyde and Gilbert Griffiths, controls the plot of *An American Tragedy* by first making Clyde's uncle "want to do a little something for him" (p. 176) and later causing the mistaken encounter with Sondra Finchley "which in so far as he and the Griffiths were concerned was destined to bring about a chain of events which none of them could possibly have foreseen" (pp. 331 ff.). Nevertheless, for all his interest in the "chemism" of life processes, Theodore Dreiser evidences no awareness of the submicroscopic genetic mechanisms that may account at once for likenesses and dissimilarities within families, and he is almost as surprised as a midwife at the distance offspring sometimes overleap their ancestral stock. Minka Nowak, who calls herself Antoinette, "had blossomed forth into something exceptional, as American children of foreign parents are wont to do."

> "I don't know how it is," she said, quite solemnly. "I have a brother who is quite as American as I am. We don't either of us look like our father or mother."
>
> (*The Titan,* pp. 129, 131)

Like his predecessors of the nineteenth century in naturalistic fiction, Theodore Dreiser has a much clearer understanding of the effects of environment, which can be more or less directly observed and experienced, than of heredity upon human personality. He is pre-eminently the novelist of city life. His characters do not merely work out their destinies in cities; they are largely the creatures of those cities: New York, Philadelphia, above all the Chicago of Dreiser's own formative years.

> The city has its cunning wiles, no less than the infinitely smaller and more human tempter. There are large forces which allure with all the soulfulness of expression possible in the most cultured human. The gleam of a thousand lights is often as effective as the persuasive light in a wooing and fascinating eye. (*Sister Carrie,* p. 2)
>
> Claudia Carlstadt . . . was . . . as ruthless and unconsciously cruel as only the avaricious and unthinking type—unthinking in the larger philosophic meaning of the word—can be. To grasp the reason for her being, one would have had to see the spiritless South Halstead Street world from which she had sprung—one of those neighborhoods of old, cracked, and battered houses where slatterns trudge to and fro with beer-cans and shutters swing on broken hinges.
>
> (*The Titan,* p. 332)

No American author has been more aware of the shaping power of special environments, such as that of the hotel in which Clyde Griffiths learns the way of the world, or even of private houses—

> We think we are individual, separate, above houses and material objects generally; but there is a subtle connection which makes them reflect us quite as much as we reflect them. They lend dignity, subtlety, force, each to the other, and what beauty, or lack of it, there is, is shot back and forth from one to the other as a shuttle in a loom, weaving, weaving. Cut the thread, separate a man from that which is rightfully his own, characteristic of him, and you have a peculiar figure, half success, half failure, much as a spider without its web, which will never be its whole self again until all its dignities and emoluments are restored.[3]

When Caroline Meeber is induced to accept Charles Drouet as protector, the voice of her conscience—"only an average little conscience, a thing which represented the world, her past environment, habit, convention, in a confused way"—is unable to assert itself in the teeth of poverty and a Chicago winter: "It was somewhat clear in utterance at first, but never wholly convincing. There was always an answer, always the December days threatened. She was alone; she was desireful; she was fearful of the whistling wind. The voice of want made answer for her." (*Sister Carrie*, pp. 103-104.)

Lester Kane is explained as "the natural product" of "an age in which the impact of materialized forces is well-nigh irresistible; the spiritual nature is overwhelmed by the shock" and "of a combination of elements—religious, commercial, social—modified by that pervading atmosphere of liberty in our national life which is productive of almost uncounted freedom of thought and action" (*Jennie Gerhardt*, pp. 132-133). Mrs. Gerhardt, confronted with Jennie's decision to go to New York with Kane, "acquiesced from sheer force of circumstances" (*ibid.*, p. 170); and the eventual dissolution of the liaison is treated as an instance of "mutual compatibility broken or disrupted by untoward conditions which in themselves have so little to do with the real force and beauty of the relationship itself" (*ibid.*, p. 368).

> "I want to tell you something, Jennie," said Lester . . . "I've thought of you right along since I left. . . . It isn't myself that's important in this transaction apparently; the individual doesn't count much in the situation. I don't know whether you see what I'm driving at, but all of us are more or less pawns. We're moved about like chessmen by circumstances over which we have no control."
>
> (*ibid.*, pp. 400-401)

At the end, Jennie sees her life as "a patchwork of conditions made and affected by these things which she saw—wealth and force—which had found her unfit . . . This panoply of power had been paraded before her since childhood. . . . Lester had been of it. Him it respected. Of her it knew nothing." (*Ibid.*, p. 430.)

Eugene Witla, particularly in his conduct with Suzanne Dale, "was no subtle schemer and planner, but rather an easy natured soul, who drifted here and there with all the tides and favorable or unfavorable winds of circumstance" (*The "Genius,"* p. 602). Clyde Griffiths "was as interesting[4] an illustration of the enormous handicaps imposed by ignorance, youth, poverty and fear as one could have found"; likewise, his unfortunate sister Esta "as he now saw it, had been brought no lower than he by circumstances over which she probably had no more control"; and their father, Asa Griffiths, "was one of those poorly integrated and correlated organisms, the product of an environment and a religious theory . . ." (*An American Tragedy*, pp. 418, 180, 22).

Must, then, the simple conclusion be reached that Theodore Dreiser was literary spokesman for a Determinism of which heredity (somewhat poorly understood) and environment (considerably better comprehended) were the mutually operative determinants?[5] Many passages, in addition to those already noted, weigh heavily in that balance. Words like "fate" readily flow from his pen: "Here was this boy [Bass Gerhardt] arrested and fined for what fate was practically driving him to do." (*Jennie Gerhardt,* p. 75.) "So much for the effect of wealth, beauty, the peculiar social state to which he [Clyde Griffiths] most aspired, on a temperament that was as fluid and unstable as water." (*An American Tragedy,* p. 338.) "That worthy [Drouet] had his future fixed for him beyond a peradventure. He could not help what he was going to do." (*Sister Carrie,* p. 85.) "What he [Cowperwood] was now planning must be as it was because it sprang out of conditions which life itself, operating through him and others, had created and shaped, and in any event not to be changed now." (*The Stoic,* p. 47.) The authentic Dreiserianism of these quotations, even read out of context, is unmistakable.

And yet there is no way to make Dreiser consistent with himself except to interpret him, like Ibsen, as more an asker than an answerer of questions. Never was an eager seeker for truth more poorly equipped with technical skills and information, or indeed with any positive qualifications for the search save honesty, courage, and earnest persistence. He had read or, rather, read in—how widely or deeply is difficult to estimate—the skeptical and pessimistic science, philosophy, and literature of the second half of the nineteenth century and the early years of the twentieth. Negatively, his religious upbringing had made him suspicious of dogmatic truths and logical certainties. Battling the world from the wrong side of the tracks, he finally surmounted both the stumbling-blocks of personal deficiency and the barricades of censorship and derogation, to achieve a universally recognized eminence in American letters. The struggle gave him to think furiously, though not systematically. All his writings were variations upon a single theme, which he named in the second part of the title of *Hey Rub-a-Dub-Dub: A BOOK OF THE MYSTERY AND WONDER AND TERROR OF LIFE.*[6] Until one has pondered well the implications of that awesome subtitle, one had best not try to generalize the intellectual attitude and philosophical conclusions of Theodore Dreiser. He was, himself, certain of only what experience taught Solon Barnes: "Life was very strange." (*The Bulwark*, p. 128.) His rule-of-thumb for personality was that there is no rule:

> The most futile thing in this world is any attempt, perhaps, at exact definition of character. All individuals are a bundle of contradictions—none more so than the most capable.[7]

The variety of temperament and behavior of the five Barnes children illuminates his view of the impossibility of referring human character to a simple formula of heredity and environment.

> As for Etta and Stewart, both Solon and even Benecia eventually found them enigmas, and so they remained. They had both begun dimly to suspect that they might not easily be encompassed in any given theory of life. During Etta's infancy and early youth, Solon was compelled to realize that she was the most individual and peculiar of all . . .
>
> There are natures which, unlike those of a practical or materialistic turn, are early taken with the virus of the ideal and can never escape it. They are born so. To them the world is never the material practical thing which many take it to be, but always colorful, symphonic, exquisite—only their own adjustment to it is unsatisfactory, without that sympathetic understanding and relationship with others which they so greatly crave. Indeed from her very youngest days Etta was

> a dreamer, stricken with those strange visions of beauty which sometimes hold us all spellbound, enthralled, but without understanding. In no way in which her father, her sisters, and her brothers were wise was she wise. There is a wisdom that is related to beauty only, that concerns itself with cloud forms and the wild vines' tendrils, whose substance is not substance, but dreams only, and whose dreams are entangled with the hopes and the yearnings of all men.
>
> Etta was such a one. From her earliest days of understanding or feeling, she was living in a world quite apart. (*The Bulwark*, pp. 129-130)

The "virus of the ideal" infects Sister Carrie, Jennie Gerhardt, and Eugene Witla as well as Etta Barnes. Readers who find Dreiser's novels only a record of human automation have altogether missed the implication of such plain statements as the following, and of the fictional episodes that give them point: "Life rises to a high plane of the dramatic, and hence of the artistic, whenever and wherever in the conflict regarding material possession there enters a conception of the ideal." (*The Titan*, p. 485.) That profound and poetic sense of the Ideal, coupled with an unflagging interest in the physical circumstances of experience, baffles every effort to assimilate Theodore Dreiser and his fiction to any "ism." His lack of philosophical system and of verbal concordance is a further discomfort to the classifiers, for he jostles almost shoulder-to-shoulder, as in *The "Genius,"* phrases like "survival of the fittest" and "evolution of the race" with looser talk about "dark forces moving aimlessly" and "the race spirit," description of human relationships as "chemical affinities," and quotations of Christian Science—not to mention the somewhat petulant demand by Eugene Witla:

> Were there any fixed laws of being? Did any of the so-called naturalistic school of philosophers and scientists whom he had read know anything at all? They were always talking about the fixed laws of the universe—the unalterable laws of chemistry and physics. Why didn't chemistry or physics

> throw some light on his peculiar physical condition, on the truthful prediction of the astrologer, on the signs and portents which he had come to observe for himself as foretelling trouble or good fortune for himself[?][8]

With all allowance for the limitations of his education, and for the fact that his fictional characters are entitled to speak dramatically for themselves as well as didactically for their author, the confusions of Theodore Dreiser about evolutionary science run deep. His partial grasp is often firm enough, but partial it remains; like the blind men with the elephant, he has no encompassing vision of the whole science, or of Science as a whole. With Solon Barnes, he was "arrested by the various vegetative and insect forms obviously devised and energized by the Creative Force . . ."

> Here now . . . was . . . an exquisitely colored and designed green fly so green and translucent that it reminded one of an emerald, only it was of a much more tender and vivid texture. . . . And what was more, . . . his mind was swiftly filled with wonder, not only at the beauty of the fly, but at the wisdom and the art of the Creative Impulse that had busied itself with the creation of this physical gem. . . .
>
> Then, after bending down and examining a blade of grass here, a climbing vine there, a minute flower, lovely and yet as inexplicable as his green fly, he turned in a kind of religious awe and wonder. Surely there must be a Creative Divinity, and so a purpose, behind all of this variety and beauty and tragedy of life. For see how tragedy had descended upon him, and still he had faith, and would have.
>
> (*The Bulwark,* pp. 316-317)

In *Sister Carrie,* he hopefully viewed the process of evolution as a transition from the beast's instinctive harmony with the forces of nature, through the unsatisfactory "middle stage" of man's present situation, to an assured future state in which by reason acting through free-will man will recover the pristine perfect harmony with nature.

> We have the consolation of knowing that evolution is ever in action, that the ideal is a light that cannot fail. He will not

> forever balance thus between good and evil. When this jangle of free-will and instinct shall have been adjusted, when perfect understanding has given the former the power to replace the latter entirely, man will no longer vary. The needle of understanding will yet point steadfast and unwavering to the distant pole of truth. (pp. 83-84)

Eugene Witla, on the contrary, "once stood in a morgue and saw human bodies apparently dissolving into a kind of chemical mush, and he had said to himself then how ridiculous it was to assume that life meant anything much to the forces which were doing these things. Great chemical and physical forces were at work, which permitted, accidentally, perhaps, some little shadow-play, which would soon pass. But, oh, its presence—how sweet it was!" (*The "Genius,"* pp. 681-682.) Though less "metaphysically inclined" than Witla, Lester Kane arrived at much the same conclusion:

> In distant ages a queer thing had come to pass. There had started on its way in the form of evolution a minute cellular organism which had apparently reproduced itself by division, had early learned to combine itself with others, to organize itself into bodies, strange forms of fish, animals, and birds, and had finally learned to organize itself into man. Man, on his part, composed as he was of self-organizing cells, was pushing himself forward into comfort and different aspects of existence by means of union and organization with with other men. Why? Heaven only knew. . . . Why should he complain, why worry, why speculate?—the world was going steadily forward of its own volition, whether he would or no. Truly it was. And was there any need for him to disturb himself about it? There was not. He fancied at times that it might as well never have been started at all. "The one divine, far-off event" of the poet did not appeal to him as having any basis in fact. (*Jennie Gerhardt*, pp. 404-405)

As the preceding quotation makes evident, Dreiser's mind passed easily from physical to social evolution; apparently, he had no sense of a theoretical division or even distinction between the two. In a meditation upon the evolution of human marriage, Eugene Witla traces the institution to the raising of young by mated animals and concludes that the begetting of children is a demand laid upon him by both the "race spirit" and the "whole American spirit" (*The "Genius,"* p. 690). *The Titan,* like *The Financier,* closes with a semi-detached epilogue that glances philosophically at the career of Frank Cowperwood. It begins with an attack on professional moralists and religionists, and proceeds to a somewhat cloudy identification of the social contract with the *élan vital:*

> At the ultimate remove, God or the life force, if anything, is an equation and at its nearest expression for man—the contract social—it is that also. Its method of expression appears to be that of generating the individual, in all his glittering variety and scope, and through him progressing to the mass with its problems. In the end a balance is invariably struck wherein the mass subdues the individual or the individual the mass—for the time being. For, behold, the sea is ever dancing or raging.
>
> In the mean time there have sprung up social words and phases expressing a need of balance—of equation. These are right, justice, truth, morality, an honest mind, a pure heart—all words meaning: a balance must be struck. The strong must not be too strong; the weak not too weak. But without variation how could the balance be maintained? Nirvana! Nirvana! The ultimate, still, equation.
>
> (*The Titan,* pp. 550-551)

If the words "Only in" are supplied before "Nirvana!" the meaning will become a little clearer. For Theodore Dreiser, life was the bittersweet material-seeming and shadow-play of an unknowable and inconceivable reality. Tormented like Diogenes Teufelsdröckh in the Rue Saint-Thomas de l'Enfer, like the Wanderer he made answer with emphasis: "Canst thou fix thine eye on the morning? Be glad. And if in the ultimate it blind thee, be glad also! Thou hast lived." (*Ibid.,* p. 552.)

J. D. THOMAS

NOTES

Page references are made to the following editions of the novels of Theodore Dreiser:

Sister Carrie (New York: Boni and Liveright, 1926).
Jennie Gerhardt (Cleveland and New York: The World Publishing Company, 1951).
The Financier, rev. ed. (Cleveland and New York: The World Publishing Company, ©1940).
The Titan (Cleveland and New York: The World Publishing Company, ©1925).
The "Genius" (Cleveland and New York: The World Publishing Company, 1946).
An American Tragedy (Cleveland and New York: The World Publishing Company, ©1948).
The Bulwark (Garden City, N.Y.: Doubleday & Company, Inc., 1946).
The Stoic (Cleveland and New York: The World Publishing Company, ©1947).

1. Cf. J. D. Thomas, "The Natural Supernaturalism of Dreiser's Novels," *The Rice Institute Pamphlet*, XLIV, No. 1 (April, 1957), 112-125.
2. *In Memoriam*, lvi, st. 4; "The Dawn," st. 5.
3. *The Financier*, pp. 107-108. The reference is to the Philadelphia house of Frank Cowperwood, who is always much influenced by his houses. (Cf. *The Stoic*, pp. 255-256.) One might mention, also, the effect upon Clyde Griffiths of his first view of his Uncle Samuel's residence in Lycurgus, as well as Clyde's distaste for "the shabby home world" of Roberta Alden ("that rickety house! those toppling chimneys!") that plays a considerable part in forcing his determination to have done with her. (See *An American Tragedy*, pp. 209, 471, 473.)
4. This word ("interesting") is Dreiser's characteristic expression for what is known in literary criticism as pity and terror.
5. Recently, with special reference to *An American Tragedy*, Randall Stewart has reaffirmed the deterministic interpretation of Theodore Dreiser in "Dreiser and the Naturalistic Heresy," *Virginia Quarterly Review*, XXXIV, No. 1 (Winter, 1958), 100-116: "In the naturalistic view . . ., man is ruled by forces from without, or forces from within, or both. Some novels stress environment more than heredity . . . and some stress heredity more than environment . . . Some novels emphasize the two about equally. Social and economic conditions are very important in Theodore

Dreiser's 'An American Tragedy,' for example, but so is heredity or temperament." "The naturalistic novelist who perhaps came nearer than any other American writer of stature to going the whole way was Theodore Dreiser, and the novel which I think best exemplifies this statement is his 'American Tragedy' . . . because it is probably the most completely naturalistic of all American novels." "'An American Tragedy' illustrates perfectly the complete amoralism of the naturalistic philosophy. . . . Clyde is not responsible, in the last analysis, because he didn't make himself. And this, I fear, is the gospel according to Theodore Dreiser."

6. New York: Boni and Liveright, 1920.
7. *The Financier*, p. 90. The particular reference of this passage is to Eileen Butler at the time Frank Cowperwood began to become interested in her.
8. *The "Genius,"* pp. 361, 689, 157, 198, 690, 688 ff., 292.

Busycon perversum (Linné)
AND SOME RELATED SPECIES

INTRODUCTION

THE YEAR 1958 marked the anniversary of two most significant contributions to the field of biology; it was the two hundredth year since Linné published the tenth edition of *Systema Naturae* and the one hundredth year since Darwin and Wallace presented their first brief paper on the origin of species. To both Linné and Darwin a species was a recognizable entity that could be compared with or related to other species. To Linné the relationship was a superficial one of similarity of body parts, for Linné, like most scientists of his day, was firmly convinced of the separate creation and immutability of species. His work did, however, give an air of unity to the study of living organisms, and his personal influence was so great that his system was soon almost universally adopted.

As scientists fell to the task of refining the classification of plants and animals according to the Linnaean system, it was inevitable that speculation would arise concerning the reasons for the similarities in morphological patterns seen in related groups. A number of naturalists in the years between Linné and Darwin made brief reference to the possibility of common ancestry of related species, but, with the exception of Lamarck's brilliant but ill-fated explanation of how species might evolve, there was no consistent and well-documented attempt to explain the relationships indicated by Linnaean taxonomy.

In the years 1831-1836 when Darwin, as a young man, circled the earth as naturalist on the *Beagle,* he first became convinced of the origin of species through common descent.

He spent the next twenty-two years carefully accumulating all the data he could find which might have some bearing on the problem. It was his intention (and an admirable one when compared with the haste with which most modern authors dash into print) to have his theory so thoroughly documented when presented to the public that there could be little doubt of its evident truth.

It came as a blow to Darwin, when in 1858 he received a letter from A. R. Wallace, a young naturalist in the East Indies, in which there was outlined the framework of a theory of evolution almost identical with the one to which Darwin had devoted so many years of painstaking study. Darwin's first inclination was to abandon his years of research and to leave the field to Wallace. His friends prevailed upon him, however, to join with Wallace, and in 1858 they presented their brief paper to the Linnaean Society of London.

In the months that followed, Darwin worked with uncharacteristic haste, and in 1859 there appeared the first edition of his *Origin of Species*. This edition was quickly sold out, and in rapid succession came the many re-issues and revisions which attested to the significance of the work. It is a matter of justice that Darwin has received the major credit for the theory which now bears his name, for without the abundant supporting evidence he supplied, the framework of a theory proposed by Wallace would have received little support.

Of course, not all contemporary scientists agreed with Darwin; there were even those who bitterly and vociferously opposed the idea of evolution from common ancestry. It is true that the theory had its weaknesses. Darwin recognized them himself; he even devoted a section of his book toward a severe criticism of his own theory. The basic truth of what he wrote, however, was undeniable, and a great portion of biological research of the past hundred years has been directed along lines that have led to an understanding of the mechanisms involved in Darwinian evolution.

A basic feature of evolution, according to Darwin's theory, has been the slow and gradual accumulation of small inheritable changes over a long period of time. Near the turn of the century, however, Hugo De Vries and others noted the occasional occurrence of large inheritable changes which they termed mutations. These mutations could apparently lead to the formation of a new species in a single generation, and the possibilities of a theory of evolution based on large mutations were so attractive that Darwin's theory fell into temporary eclipse.

Early in the twentieth century, certain groups of scientists began conducting experiments which they claimed showed that acquired characteristics could be inherited. This school of thought, now often referred to as Neo-Lamarckianism, survives today as the official biological credo of Soviet Russia.

In recent years, however, increasing knowledge in the field of genetics has provided the necessary mechanism for explaining evolution in Darwinian terms, and most of the present students of evolution refer to themselves as Neo-Darwinians. Evolution is thus regarded as occurring in many small steps and in many places, with the environment selecting those individuals with the most suitable genotype for any given time or place.

Although it now appears evident that most evolution has proceeded along the lines indicated by Darwin, there is still the possibility that evolution and species formation might occasionally be accomplished by other methods. In the following paper on some species in the genus *Busycon,* a means is indicated whereby reproductively isolated species could be produced in a single generation. This process might even happen several times in similar fashion and thus lead to two or more homologous species, each derived from the same ancestral stock.

In this one hundredth anniversary year of the presentation of Darwin's theory, it is fitting that research is still being conducted along lines similar to those outlined by Darwin himself. It is sincerely hoped that the two following papers would interest Darwin if he could be here to read them, for it is in his honor that they are presented.

* * * * * * *

The genus *Busycon* today includes several species of large marine snails, commonly called whelks, which live along the Atlantic and Gulf Coasts from Cape Cod, Massachusetts to the Yucatan Peninsula. The group had its origin in late Cretaceous or early Tertiary time, reached a maximum number of species by the Miocene, and has been in slow decline ever since.

The genus has apparently always been restricted to the continental shores of North and Central America, for it has never been taken, either living or fossil, from any of the Bahamas or West Indian Islands. It is common on the Tortugas and the Campeche Banks, and its absence from Cuba and the Bahamas, which are very similar both ecologically and faunistically, must be due to the inability of the eggs or young snails to cross the Gulf Stream.

There is no free larval stage, but the egg cases, consisting of hollow disks attached together in long spiral coils, are common objects along all our Gulf and Atlantic shores. Within each disk, a few dozen young snails are produced, each with a small but dense shell. The parent female attaches the egg cases by burying the lower end of the case in a sandy or muddy bottom, but even if the cases are torn free, they are denser than the sea water and will not float.

Widespread distribution is difficult or impossible not only for young specimens but also for the adults. The food of *Busycon* consists largely of clams which live buried in a sandy or muddy bottom that is soft enough for the *Busycon* to plough its way through. Stiff clay or rocky bottom is unsuitable, and only rarely has *Busycon* been taken from such a substrate. Even on a favorable bottom the rate of movement is slow. Magalhaes (1948) reported from field observations that many specimens of *Busycon* did not move laterally at all; on some days they would merely emerge from the sand and then burrow back into it. Of those specimens which did move, the average distance traveled was 18 meters per day.

Three other significant facts concerning the biology of *Busycon* were reported by Magalhaes (1948): (1) The density of population is relatively sparse for a marine invertebrate. Even on the most favorable bottom available in the area of Beaufort, North Carolina, there was only one specimen of *Busycon* for each 80 square feet. (2) Growth is slow; for *Busycon carica* (Gmelin) the formation of a single shoulder spine required from 94 to 501 days. An average adult snail, 4 to 5 inches long, has 10 to 12 spines on the body whorl alone, and at this rate of growth, the formation of the last whorl would require from 3 to 15 years. (3) There is a breeding season for *Busycon carica* (Gmelin) in the spring and another in the fall, although it is not known whether the same female will produce egg cases at both seasons. At any rate, the reproductive potential is high, for a single large egg case will house 4,000 to 6,000 eggs.

The species of *Busycon* can thus be represented as being made up of small, highly localized populations of slow-growing but long-lived individuals. Gene flow between adjacent populations is slow, and for many of these populations it must be negligible.

If the genes of *Busycon* were as stable as they apparently are for such animals as *Limulus,* the horseshoe crab, or *Lingula,* the brachiopod, the various populations of *Busycon* might all be morphologically uniform; such is not the case. Not only is there considerable difference in the general form, coloring, and sculpture of the various members of a single population, but there are also marked differences in these features in a single individual as it passes through its young, mature, and gerontic stages.

Although there is considerable range in the variability of the members of a given population, there is frequently a much greater range in variation between different populations. It should be noted, however, that some populations are remarkably uniform, and, although intergrades with adjacent populations do occur, most of the individuals are easily recognizable.

Of particular interest in a study of the genus *Busycon* is the repeated appearance in different populations (or even species) of the same mutations or gene recombinations. Although most of the species are dextral, or right-handed, there are a few sinistral, or left-handed, species. Usually, for each sinistral species there is a corresponding dextral species that is so similar that one must be regarded as having been derived from the other. Fossil examples of reversed species pairs are *Busycon filosum* Conrad and *Busycon obfilosum* (Grabau) from the Miocene and *Busycon rapum* (Heilprin) and *Busycon obrapum* (Grabau) for the Miocene-Pliocene. In the recent fauna *Busycon perversum* (Linné) is the sinistral counterpart of the dextral species *Busycon carica* (Gmelin) and *Busycon candelabrum* (Lamarck).

Although reversed individuals of a species are rare, they are known to occur. Sinistral examples of *Busycon canaliculatum* (Linné) have been reported by Abbott (1954). A sinistral example of *Busycon coarctatum* (Sowerby) was reported in Sowerby's original description of that species. Hollister (1958) reported a dextral specimen of *Busycon perversum* (Linné) from Fort Myers, Florida, and stated that experienced collectors from West Florida had seen other examples. M. Smith (1941) also reported a dextral *Busycon perversum* (Linné) from the east coast of Florida, but Hollister (1958) stated that it was a young *Busycon carica* (Gmelin).

Another anomaly that has been produced repeatedly is the presence of two rows of spines on the shoulder. Such individuals have been reported in *Busycon carica* (Gmelin) by Hackney (1944), Magalhaes (1948), and Hollister (1958). A similar abnormality in *Busycon perversum* (Linné) was reported by Burnett Smith (1944).

In the southern part of the range of both *Busycon carica* (Gmelin) and *Busycon perversum* (Linné) there occurs a population in which the shell is thicker and heavier than usual, and a swollen ridge extends diagonally across the siphonal canal. Intergrades of all degrees between these heavy shells and the more usual forms are frequent enough to indicate interbreeding without impaired fertility in the offspring. Occasional isolated individuals of *Busycon perversum* (Linné) with the heavy shell and diagonal ridge have been reported from West Florida, and somewhat heavier shells with fairly well developed ridges are known from the Texas Coast.

On the basis of the preceding information regarding intergradation, it is believed that all of the recent sinistral Busycons belong to a single species, *Busycon perversum* (Linné). The range of this species extends along the coast from Cape Hatteras, North Carolina, around the tip of Florida, and westward and southward in the Gulf of Mexico to the Straits of Yucatan. As is to be expected in a species with such an extensive range, particularly a species with the population structure and genetic constitution present in the Busycons, there is considerable geographic variation, and a few of these populations perhaps warrant designation as subspecies.

On the Atlantic coast from Cape Cod, Massachusetts, to Cape Canaveral, Florida, there is a dextral Busycon, resembling a reversed *Busycon perversum* (Linné), which has long been known as *Busycon carica* (Gmelin), although Hollister (1958) has attempted to fix the name *Busycon aruanum* (Linné) on it. The shell of this species in the northern part of its range is thin, chalky, and with small rounded knobs at the shoulder. To the southward, the shell gets heavier, porcelaneous, and spinose. In the extreme southern part of the range the shell is not only quite heavy but it also has a swollen ridge extending diagonally across the siphonal canal. Since all of these characteristics change so gradually through the range of the species, it is probably best to regard it as a clinal change and not attempt to establish subspecies.

In the Western Gulf of Mexico from Texas to Obregon, Mexico in depths of 25 to 35 fathoms there is another dextral *Busycon* which also resembles a reversed *Busycon perversum* (Linné). It was even referred to as such by Rehder and Abbott (1951), but Hollister (1958) has identified it with *Busycon candelabrum* (Lamarck). This species also shows considerable variation, particularly in regard to the relative length of the siphonal canal and the number of spines at the shoulder. Since none of this variation is known to follow any geographic pattern of distribution, the species should not be divided into subspecies.

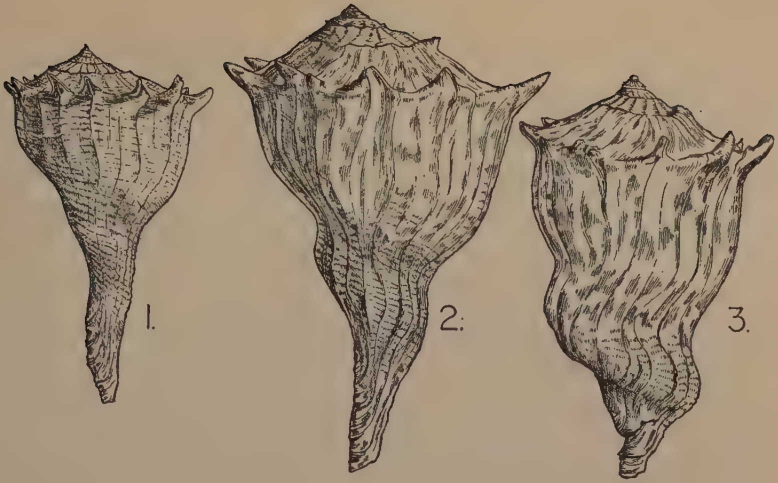
Both *Busycon perversum* (Linné) and *Busycon carica*

(Gmelin) are known from as far back as the Miocene, but *Busycon candelabrum* (Lamarck) has not been reported in the fossil state. The greater geographic range of *Busycon perversum* (Linné), and the fact that dextral examples of it are known to occur, make it seem likely that this is the parent species from which the two dextral species have evolved. It is here suggested that the peculiar condition of asymmetry in the Gastropods has made it possible for bisexual forms, such as *Busycon,* to develop reproductively isolated species in a single generation.

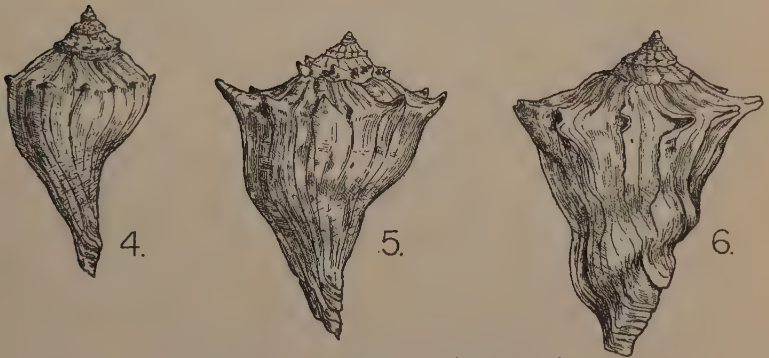
The copulatory organs of *Busycon* are asymmetrically located on the side of the head in the mantle cavity. Although no breeding experiments have been attempted between dextral and sinistral specimens, it is apparent that there must be some degree of mechanical difficulty in copulation. Even if this difficulty is only slight, it would probably be sufficient to prevent free gene flow between dextral and sinistral populations. The occasional dextral examples of *Busycon perversum* (Linné) that are reported today, must be unique individuals without hope of posterity. In the past, however, two such individuals must have occurred at the same time and place somewhere along the Atlantic coast, and their progeny became the species *Busycon carica* (Gmelin).

A similar event must have also occurred independently in the western Gulf of Mexico to have produced *Busycon candelabrum* (Lamarck). In all three species, similar variations in the general form, coloring, spine development, and sculpture have been produced. The only well marked possible combination that has not yet been discovered is a *Busycon candelabrum* (Lamarck) with a heavy shell and a swollen diagonal ridge across the siphonal canal.

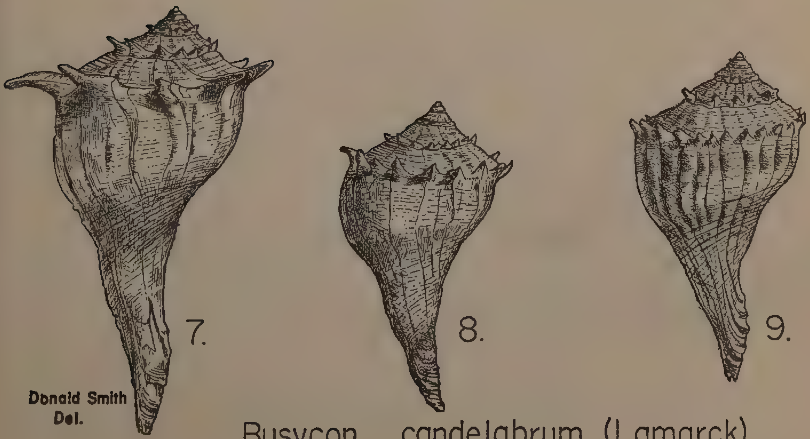
From the foregoing account it is evident that I regard a



Busycon perversum (Linne)



Busycon carica (Gmelin)



Donald Smith
Del.

Busycon candelabrum (Lamarck)

species, as do most modern systematists, as a biological reality. It can be defined, with certain minor exceptions, as a self-reproducing population (or populations) of common descent and reproductively isolated from other similar populations. It is recognized that this definition is difficult to apply to asexual species or to populations occurring in geological sequences through long periods of time. Since it is possible to define a species in non-arbitrary terms only at a given time level (usually the recent), it should perhaps be recognized that there is a double standard for paleontologists and students of recent species. The definition of a species given by Knight (1941) can be paraphrased briefly as the type specimen and all other specimens regarded by some authority as conspecific with it. By this definition a species is an abstraction with arbitrarily assigned man-made limits, useful for purposes of communication between specialists, but having no reality in nature. Few, if any, systematists working with recent species would agree with this definition, but it is perhaps the best that can be done for the paleontologists.

On the basis of the preceding remarks I present the following descriptions and synonymies of three species of *Busycon.* Like most of the other species in the genus, they have had a troubled history, and it is hoped that this paper will clarify the picture somewhat.

Busycon perversum (Linné)

Figures 1-3

Murex perversus Linne, 1758, Syst. Nat., ed. 10, p. 573, no. 485, Gualt. test. t. 30, f. B., Argenv. conch. t. 18, f. F.

Pyrula perversa var., Kiener, 1840 Spec. Gen. et Icon. des Coq. Viv., Vol. 6, *Pyrula,* pp. 7 and 8, pl. 9, fig. 2.

Pyrula kieneri Philippi, 1848, Zeitschr. f. Malak., p. 98. (Refers to the figure of Kiener)

Fulgur gibbosum Conrad, 1854, Proc. Acad. Nat. Sci. Phila., vol. 6, p. 319. (Also refers to the figure of Kiener)

Busycon (Sinistrofulgur) sinistrum Hollister, 1958, Palaeont. Amer., Vol. 4, p. 85, pl. 11, figs. 1-4, 10, 12, pl. 12, fig. 11, pl. 13, figs. 6-9.

Busycon (Sinistrofulgur) pulleyi Hollister, 1958, Palaeont. Amer., Vol. 4, p. 89, pl. 11, figs. 7, 8, 11, pl. 12, figs. 7-10, pl. 13, fig. 10.

Busycon (Sinistrofulgur) aspinosum Hollister, 1958, Palaeont. Amer., Vol. 4, p. 90, pl. 13, figs. 3-5.

In his original brief description of this species, Linné referred to two figures: the one by Gualtieri represents the slender form common throughout most of the range of the species, and the one by D'Argenville is the heavy form with a ridge on the siphonal canal. The description is so brief that it could refer to either form. Kiener, in his descriptions of the genus *Pyrula,* included a figure of a heavy shell from Campeche which he called *Pyrula perversa* variety. Philippi based his description of *Pyrula kieneri* on this figure of Kiener's and he was thus the first to apply a separate name to one portion of Linné's *Murex perversus.* Conrad also referred in his description of *Fulgur gibbosum* to the same figure of Kiener's. For many years the slender form of the shell was known as *Busycon perversum* (Linné) and the heavy, distorted form from Campeche was variously referred to as *Busycon kieneri* (Philippi) or *Busycon perversum kieneri* (Philippi).

Burnett Smith (1939) assumed, on the basis of a lack of intergrades between the two forms, that they represented two different species. He was working with a limited collection from Campeche, however, and more recent collections made by shrimpers working in that area show that all degrees of intergradation do occur. (See fig. 2, of a shell from Campeche.) It is claimed by some of the shrimpers that in a limited area west of Obregon, Mexico, and in depths out to 18 fathoms, the population consists almost entirely of the heavy form with the swollen canal. (See fig. 3.) Elsewhere in the Campeche area the usual slender form prevails (see fig. 1), with an occasional specimen showing a marked tendency toward the ridge on the canal. On the basis of this evidence of interbreeding, it must be assumed that the two forms are conspecific, although the heavy shelled population from west of Obregon should perhaps be regarded as a distinct subspecies.

Burnett Smith (1939), and more recently Dodge (1957) and Hollister (1958), have assumed that the specimen of this species in the Linnaean collection in London is to be regarded as the type of the species. A type, however, is a specimen that an author has in his possession at the time he writes his description and on which the description is based. Furthermore, the concept of type specimens is a recent innovation and should be used retroactively only with extreme caution. It is known that specimens in early collections were frequently replaced by other specimens, frequently of other species. The collection for the Museum Ulricae has admittedly been better cared for than Linné's own collection, and yet the specimen of *Busycon perversum* in that collection is known [See Hollister (1958)] not to be the one which Linné described for Queen Ulrica of Sweden. The specimen in Linné's collection is of the heavy shelled variety and bears the number 557, but this is the number used for the species in the 12th edition, not in the original description. The digit 7 inscribed on the shell does not have the cross-bar on the shaft as would be expected in the writing of a continental European. After Linné's death, his collection was held for a time by his son and then given to

Sir James Smith, a British botanist, who perhaps added the numbers, or even the specimen.

Since there is doubt that the specimen in the Linnaean collection is the type, Philippi (1848) can be accepted as the first reviser, and the heavy shell from west of Obregon illustrated on figure 3 should take the name *Busycon perversum kieneri* (Philippi) with *Fulgur gibbosum* Conrad as a junior synonym. The common slender form is then left as *Busycon perversum perversum* (Linné).

Busycon (Sinistrofulgur) pulleyi Hollister is merely a form which is somewhat more spinose and with a slightly turreted spire. Individuals which fit this description occur along the Texas coast and less frequently elsewhere, but since they occur with, and intergrade with, the usual *Busycon perversum perversum* (Linné), they should probably be referred to that subspecies. Future statistical studies of this form may warrant giving it separate subspecific rank as *Busycon perversum pulleyi* (Hollister).

Busycon (Sinistrofulgur) aspinosum Hollister is based on 9 unusual specimens in one lot from Longboat Key, Sarasota, Florida. These are spineless aberrants (mutants?) from a normal population of *Busycon perversum perversum* (Linné) and should not receive even subspecific designation.

If future events should lead to a recognition of the specimen in Linné's collection as the type of *Murex perversus* Linné, then the slender shell will take the name *Busycon perversum sinistrum* (Hollister) with *Busycon pulleyi* Hollister and *Busycon aspinosum* Hollister as synonyms. The heavy shell from west of Obregon will be called *Busycon perversum perversum* (Linné) with *Pyrula kieneri* Philippi and *Fulgur gibbosum* Conrad as synonyms.

Busycon carica (Gmelin)

Figures 4-6

Murex aruanus Linné, 1758, Syst. Nat., ed. 10, p. 753, no. 484 (in part). Rumph. mus. t. 28, f. A. Not Gualt. test. t. 47, f. B.

Murex carica Gmelin, 1791, Syst. Nat., ed. 13, part 6, p. 3545.

Fulgur eliceans Montfort, 1810, Conch. Syst., Vol. 2, pp. 502-504, fig.

This right-handed *Busycon* occurs on the Atlantic coast of North America from Cape Cod to Cape Canaveral. It was first described by Linné (1758) as a part of a composite species which he named *Murex aruanus*. His complete original description of this species can be translated as "*Murex* shell with an open siphonal canal; spire spinous-coronate. Lives in New Guinea." Of his two figure references, the one by Gualtieri is of the Atlantic coast species, and the figure by Rumphius shows a species of an Indo-Pacific shell now placed in the genus *Megalatractus*. There was no specimen of either species in Linné's collection at the time the 10th edition was written (Fide Hanley 1855), so there can of course be no type. A great deal of speculation has ensued regarding what Linné had in mind when he described this species, but the safest thing to assume is that he meant no more nor less than what he said; he was merely giving a name to two figures which he thought represented the same species. Although the expression "spinous-coronate" does not refer very accurately to the Indo-Pacific shell, it could very easily be used in describing the figure given by Rumphius. In fact, the brief description in the 10th edition could be applied equally well to either of the cited figures. The only part of the original description that definitely serves to separate the two species is the type locality and the trivial name itself. Rumphius had called his shell *Buccinum aruanum* and said that it came from the island of Aru in the East Indies. Linné's use of Rumphius' name, and his citation of New Guinea as type locality, would certainly seem to indicate Linné's intention of this name for an Indo-Pacific species. In this connection, Opinion 52 of the International Commission is pertinent: "The citation of the type locality of a species is not sufficient to establish a name under article 25a of the code. If specific characters are given in addition to the type locality, the type locality becomes a part of the description and is to be considered as an important element in determining the identity of the species."

At any rate, in his later publications Linné never attempted to separate the Indo-Pacific from the American species.

Born (1780) and Schroeter (1783) both attempted to purge the reference to Gualtieri's figure of the Atlantic coast shell from Linné's description of *Murex aruanus,* and to fix that name on the Indo-Pacific species. There are various objections to the method by which this was attempted [See Hollister (1958)], but Gmelin (1791) certainly achieved separation when he erected the new name, *Murex carica,* for the Atlantic species and cited the figure of Gualtieri that had previously confused Linné's description of *Murex aruanus.* Gmelin also cited other figures, all of the east coast species, for *Murex carica.* His description and figure references for *Murex aruanus* clearly indicated the Indo-Pacific species.

Hollister (1958) objects to Gmelin as first reviser of Linné's composite species on the grounds that Gmelin included in his description of *Murex aruanus* a restatement of Linné's original description and a reference in the synonymy to Linné's later description of the species in the Museum Ulricae. As has previously been pointed out, Linné's first description could apply to either species, and the later description fails to separate the two. Otherwise, Gmelin's description and figure references of *Murex aruanus* clearly indicate only the Indo-Pacific species. It hardly seems reasonable, therefore, to reject Gmelin's interpretation of *Murex aruanus* on the grounds of a single doubtful reference in the synonymy.

Even if Gmelin's determination of *Murex aruanus* is not accepted, his description and figure references of *Murex carica* were unequivocal and referred only to the Atlantic coast species. Hollister (1958) objected to this description, however, on the grounds that Gmelin failed to include any reference to Linné's species in his synonymy.

It is not likely that many taxonomists will agree that Gmelin's description of these two species should not be considered as an adequate revision. Objections that in one description he included a doubtful reference in the synonymy and that a reference was omitted from the synonymy of the other certainly seem to be trivial.

On the basis of the previous discussion, the following conclusions seem to be warranted: (1) Linné included two species in his original description of *Murex aruanus,* and there is no evidence that he was ever aware of this error. (2) Even if Born and Schroeter failed to achieve separation of the species by fixing the name *aruanus* on the Indo-Pacific form, Gmelin certainly did by setting up two species, and he should be recognized as the first reviser. (3) The name *carica* applies to the Atlantic coast *Busycon,* and *aruanus* to the Indo-Pacific species.

Busycon carica (Gmelin) lives today in shallow water along the Atlantic coast from Cape Cod, Massachusetts, to Cape Canaveral, Florida. In the northern part of the range the shell is thin, chalky, and with many small knob-like spines on the shoulder. (See fig. 4.) To the south, the shell gets progressively heavier, porcelaneous, and with fewer but larger spines

(See fig. 5.) In this form, frequently seen in the Carolinas, *Busycon carica* (Gmelin) looks strikingly like a reversed *Busycon perversum* (Linné). This resemblance is particularly marked in the younger stages of the two species.

In the southern part of South Carolina and in northern Florida the shell is very much heavier and a swollen diagonal ridge crosses the siphonal canal. In this form (see fig. 6) *Busycon carica* (Gmelin) looks so much like a reversed *Busycon perversum kieneri* (Philippi) that various authors have suggested that they are dextral and sinistral manifestations of a single species. Although this heavy southern form of *Busycon carica* (Gmelin) has often been referred to as *Busycon eliceans* (Montfort) or *Busycon carica eliceans* (Montfort), the shell described by Montfort was more like the one shown in figure 5 from the middle part of the range of the species.

The characteristics of this shell change gradually from one part of the range to another, and in most of the range a variety of forms is present. This type of change in which the degree of difference is proportional to distance is properly referred to as a cline, and the species should not be broken up into subspecies. The description of the species should be extensive enough to include the variations in the different parts of the range. At any rate, the name *eliceans* refers to the population from the middle part of the range, and no name is available (nor should any be proposed) for the heavy-shelled southern form with the ridge on the canal.

Busycon candelabrum (Lamarck)

Figures 7-9

Pyrula candelabrum Lamarck, 1816, Encycl. Meth., Liste, p. 8, pl. 437, f. 3.

This species has been so little known that it has not suffered the unfortunate confusion of names that has been the lot of most species of *Busycon*. It apparently lives in deeper water than other Busycons, and until recently has been extremely rare in collections. The shrimp boats now operating on the Campeche Banks report that it is fairly common, however, on the deeper part of the grounds off Obregon, Mexico. In depths of 25-30 fathoms it occurs in some abundance in association with a few *Busycon perversum* (Linné), mostly of the slender form.

There are scattered records of *Busycon candelabrum* (Lamarck) from off the Texas and nothern Mexican coast, mostly in depths of 25 fathoms or more. In a recent series of dredge hauls made at Stetson Bank off Galveston, Texas, in depths of 30-35 fathoms, many fresh fragments were obtained, and a live specimen was taken from nearby Claypile Bank. These Texas specimens resemble mirror images of the slender form of *Busycon perversum* (Linné) which is common further inshore.

Some of the shells of *Busycon candelabrum* (Lamarck) from off Obregon, Mexico, also look like reversed *Busycon perversum* (Linné), but most of the specimens from this area are marked by a great many more small spines at the shoulder and a somewhat longer siphonal canal, particularly in the larger stages. The three figures (7, 8, and 9) on the bottom of the illustrative plate are all made from specimens taken off Obregon, Mexico. Figure 9 represents the most common form, with figures 7 and 8 illustrating the range of variability in spinosity and the form of the siphonal canal.

In all three species of *Busycon* discussed in this paper there are internal raised spiral lines which stop short of the upper and outer lips of the aperture. There is a similar raised line on the columella, just below its junction with the upper lip. These lines are often obsolete or missing entirely (particularly in older specimens) in *Busycon carica* (Gmelin) and

Busycon perversum (Linné). In *Busycon candelabrum* (Lamarck), however, these lines are sharp and distinct inside both the outer and upper lips, even in the largest specimens examined. The constant presence of these spiral lines and the greatly increased spinosity, in addition to the dextral condition, all suggest the distinctness of *Busycon candelabrum* (Lamarck) as a separate species from *Busycon perversum* (Linné).

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NOTES ON THE ORIGIN OF BONY ARMOR[*]

DARWIN'S eager search for origins and the dramatic pulse given to the study of the unfolding of life which arose as a result of his physical and intellectual voyages has since encouraged the investigation of obscure comparative phenomena as related to the organic world. Whether the concern exists for the explanation of the hereditary process as a biochemical mechanism or the defense of a family tree of fossil horses, the student begins his research secure in the belief that the complex arises from the simple and that the causal factors governing the changes in presently observed phenomena may be, in a large measure, extended into the past. Consequently this inquiry into certain early stages in the development of the vertebrate skeletal system must start with a review of the functional and developmental aspects of living animals. Anatomical characters may be compared directly, but functional characteristics become less confirmable as one examines unfamiliar fossil organisms. Not infrequently, however, living primitive forms bear an astonishing resemblance to those of the remote past. Such ancient fragments as scales, plates, and teeth of extinct fish packed in the sands of an Ordovician bay present a challenging early exhibit in the testimony offered by fossil bone. These elements are intact as to general anatomic structure, and after over 400 millions of years retain the fundamental mineral crystal pattern. Such stability of form conveys microscopic details of the channels for nerves, blood vessels and fibres much as they existed in the living organism.

Bone, then, is a sediment within the provincial system of

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[*] This project, including the field work, was supported by the Department of Geology of the Rice Institute.

the vertebrate body and finally becomes a sedimentary rock in the terms of the geologist. Comprised of the mineral apatite, its structure has long been known through studies of X ray diffraction patterns. Both in the living body and in vitro this remarkable mineral presents huge surfaces for reaction with its small crystals set within the collagen framework of the body. A length of 200-780 angstrom units, a width of 30-50, and a thickness of 20-50 yield a computed surface area of nearly 100 acres for a man of average weight.[1] The tremendous surfaces offered result in much interchange between the components of the apatite lattice and the body fluids and even after death this tissue responds to the action of waters held in the sediments. The following experiments are illustrative:

Work with rabbits[2] involved the maintenance of a relatively constant level of labeled phosphate in the blood plasma and a measurement in the skeleton after a fifty-day period. This constituted an excellent test of the mobility of bone phosphorus; one fourth of this element was replaced in the actively growing ends of the limb bones, forty percent in the shoulder blade, and a complete turnover in the actively growing incisor tooth root.

In the test tube,[3] phosphorus 32 was placed in solution in a measured amount and its exchange with skeletal tissues and synthetic apatite was noted. After a period of eight hours, thirty percent of the active element was found in the bone, less than twenty-five percent in the apatite, slightly more than five percent in a sample of dentine, and one percent in tooth enamel.

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[1] Robinson and Watson (1952); (1955); McLean (1958).

[2] Hevesy, Levi and Rebbe (1940).

[3] Falkenheim, Neumann and Hodge (1947).

It is evident that the soft organic tissues, particularly collagen and chondroitin sulfate, serve as binding materials for the minerals. Divorced from the body, the skeletal system continues to show a greater capacity to react than the synthetic mineral component. Resistant combinations of fiber and minerals as found in the teeth are more stable than other parts of the hard anatomy, and consequently teeth or tooth-like structures, and homologs such as the more primitive integument of fish, are preserved with little modification through hundreds of millions of years.

The climate of the internal animal is modified by glands of internal secretion. Many of these regulators affect bone salts and in the simpler vertebrates were exposed to the environmental waters. Naso-hypophysial openings were dorsally placed or opened into the oral cavity. The endostyle, traceable to the thyroid gland, is functional as an organ of nutrition both mechanically and physiologically in the lancet *(Branchiostoma)* and larval cyclostomes. Other regulatory structures in higher forms appear first in the region of the branchial or gill pouches. The parathyroid, thymus, and ultimobranchial series may well have been concerned more directly in the process of nutritional regulation in the most primitive vertebrates. It is significant that much of the tissue formerly exposed to an external fluid environment maintains its anatomical position and possibly much of its function with the internal fluids. Here most of these glands are concerned now, as in the past, with the accumulation or release of minerals of the body.

Hyperactivity of the pituitary gland results in gigantism,[4] while removal halts cartilage bone growth sequences and quickly results in effects commonly observed in old age.[5]

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[4] Becks, Simpson and Evans (1945).

[5] Evans *et al.* (1948).

Overactivity of the thyroid gland causes an increased excretion of calcium and deficiencies in bone structure (osteoporosis). Removal of the thyroid retards both growth and form of the skeleton. The closely associated parathyroids have a profound effect on mineral metabolism both in mobilizing calcium and phosphorus from the bone and possibly in the recovery of salts by way of the kidney tubules. Excess hormone from this gland results in overstimulation and destruction of bone cells, fibrous tissue formation in Haversian canals, and other pathological changes.[6]

Reproductive cycles[7] result in the activity of these glands in relation to the oestrogenic hormones, and reserves of minerals are deposited as spongy tissue in the marrow cavities of the long bones of birds, there to await the demands of egg laying. In mammals calcium is quantitatively connected to the growth rate of the young as to its availability in milk.[8] Two hundredths of a percent in humans is noted in connection with a doubling of the birth weight in 180 days. Cow's milk had 0.12 percent of calcium and the weight of the calf doubled in 47 days; while the dog, with 0.32 percent calcium in its milk, required only seven days to achieve twice the birth weight of the young.

The outer green leaves of plants constitute the primary source of calcium for most land animals and the plants depend upon the soil minerals for their growth. Loss of these minerals due to erosion, especially during regressions of the sea, could result in mineral wealth for aquatic organisms and poverty for many land forms. Changes in the fauna during Pleistocene time, when thermal changes and cyclic rise and fall of the seas strongly affected the quality of plant life, have been observed on all continents by the students of the higher mammals. Darwin in 1832 described the "perfect catacomb for monsters of extinct races" as he reviewed the Punta Alta Pleistocene remains and, with the instincts of an ecologist, attempted to account for a food supply for the varied assortment of sloths, glyptodonts, and armadillos. He accepted the anatomical findings of the famous anatomist Owen and presented the following interpretation of the habits of these giant edentates:

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[6] Becks *et al.* (1950).

[7] Snapper (1940).

[8] Bunge (1898).

> With their great tails and their huge heels firmly fixed like a tripod on the ground, they could freely exert the full force of their most powerful arms and great claws. Strongly rooted, indeed, must that tree have been which could have resisted such a force! The Mylodon, moreover, was furnished with a long extensile tongue like that of the giraffe, which, by one of those beautiful provisions of nature, thus reaches with the aid of its long neck its leafy food.

The giant sloths and most of the large edentates have become extinct after having merged in time with the coming of man to South America. The largest of vertebrates, the whales, remain to testify as to the availability of nutrients in the sea gained in part from the extensive erosional processes characteristic of the Quaternary. Erosional cycles of the early Paleozoic and the primitive plants invading the land may similarly have unlocked a mineral treasure for the early agnathous fishes. The presence of their remains near shorelines and in shallow bays and estuaries suggests that the concentration of nutrients where river meets sea was a condition which stimulated the development of early fish then as today. Certainly not the least of the factors concerned with the development of bone was the availability of minerals, and it is to be assumed that in the long period of evolution of the naked chordates and unossified early vertebrates many were attracted from the sea to fresh water. One may suppose that anadromous and catadromous habits might have been fixed prior to the appearance of a hard plate or scale integument.

Skeletal elements with minerals suspect of calcium and phosphatic components have been found in trivial numbers in Lower Ordovician deposits of Esthonia and in the Middle Cambrian St. Albans shale of Vermont[9]. Of the latter remains, the genus *Archaeognathus* may be a fibrous conodont. Most abundant[10] of these early fossils are the scales, plates, denticles, and conodonts of the Mid-Ordovician Harding Sandstone as exposed in the region of Canyon City, Colorado, and geologically related areas of the western United States. Specimens were first collected in 1877 by S. F. Eammons and I. C. Russell of the United States Geological Survey. Ably assisted by a local citizen, W. T. Stanton, they accumulated a limited associated invertebrate assemblage which led to the surprising conclusion that these rocks were Silurian or even Ordovician in age. The fragmentary fish remains naturally presented a challenge to paleontologists since they then represented the world's oldest known vertebrates.

Walcott confirmed and reported the stratigraphic observations of the previous workers and visited the locality in 1890. At that time he established contacts of the Ordovician section with underlying prepaleozoic and overlying Carboniferous limestones. Reports followed in 1891 and 1892 resulting in the descriptions of three species of fishes. Distinctively ornamented scales were placed in the species *Astraspis desiderata* and provisionally assigned to the "ganoid" suborder Placodermata. Other less ornate plates were referred to the group Crossopterygii as *Eriptychius americanus*. Fragments then mistakenly diagnosed as notochordal sheath remnants were referred to the group Chimaeroidea as the species *Dictyorhabdus priscus.* Walcott's paper was discussed by a distinguished group of paleontologists including Zittel, Claypole, Jaekel, Hall, and Cope. Their comments in some cases expressed doubts as to the affinities of the specimens and stimulated Walcott to prepare microscopic sections of the scales. These clearly showed dentine tubules, pulp cavities, lamellae, and lacunae supposedly showing the presence of osteoblasts; thus the undoubted piscine affinities of the finds were demonstrated, but the classification remained uncertain.

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[9] Orvig (1958); Howell (1937).

[10] Walcott (1892).

Cope (1893) correctly placed the specimens in the group Agnatha.

Valliant (1902) examined some material from the type locality and found spaces filled with limonite which he interpreted as evidence favoring the presence of bone cells. His specimens were not classified.

Woodward (1921) referred *Astraspis* to the Cephalaspidae on the basis of microsections. He did not figure his specimens and his brief statement contains no defense of his diagnosis.

Eastman (1917), Stensiö (1927), Stetson (1921), Bryant (1934), and Orvig (1958) agree that *Astraspis* and *Eriptychius* be assigned to the order Heterostraci of the class Agnatha. Stetson found scales in association with these genera which he classified as Coelolepids of the genus *Thelodus.*

Conodonts associated with the Canyon City fauna were studied by Kirk (1929), Branson and Mehl (1933), and Sweet (1955). Basal structures attached to conodonts were described as having the same appearance as the ostracoderm plates by Kirk, but Bryant, in a more detailed histologic study, could not confirm this observation. Branson and Mehl (1944) state:

> Most investigators assume that they represent the jaw armour of an extinct order of primitive fishes. This opinion is based on the chemical composition, nature of growth additions, and actual attachment of many specimens to jaw substance.

It is possible that the Harding conodonts may be referred to immature stages of the associated ostracoderms as internal supports for a gill raker feeding mechanism; those with a basal attachment may have persisted in adult forms. Ellison (1944) showed the apatite crystal structure to be present and a chemical composition close to that of bone. Foss (1958)* finds the Harding Sandstone conodonts and intimately associated fish plates to be quite similar as to pattern when studied by X ray diffraction techniques.

Bryant's (1936) description of the scale anatomy of *Astraspis desiderata* based on a study of thin sections shows a close relation to exist with the Drepanaspidae. He defined basal, intermediate, and superficial zones, delineating them on the basis of variations in the canal systems and the contrasts in tissue layers. Vertical canals were found basally but described as "meandering" in the middle layer. The surface of the bone was found to be tuberculate with either stellate or oval prominences. Transparent enameloid substance capping the tubercle was shown to have a hardness of 5.5 on the Moh scale. It was soluble in hydrochloric acid, had no laminar structure, and was not similar optically to enamel or ganoine. Dense acellular tissue was beneath the cap with laminae penetrated with subparallel fibres. Bryant compared these with the Fibres of Sharpey and suggested that they radiated from a pulp cavity. Stained sections gave these the appearance of very fine tubes.

Neither cell spaces nor tubulets were described for the middle layer. Vascular canals were found to open between the tubercles, the aspedin, or acellular bone, forming concentric lamellae around the vessels. Cavities resembling lacunae for osteocytes were found to be largely the results of post-mortem erosion.

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* T. H. Foss, The Rice Institute Geology Department, in MS.

The basal layer was characterized as thick with distinct parallel lamellae with usually unbranching vertical canals extending to the vascular system of the middle layer. Fibres were described extending upwards in parallel groups.

Bryant found *Eriptychius* (pl. II, 3) to have a dentine ridge ornamentation with microstructure similar to that of *Astraspis.* Coarse dentine tubules were described as branching, originating in the pulp cavity and extending to the surface.

The middle layer was acellular with a labyrinthine appearance as a result of the branching of the abundant vascular canals extending to the pulp cavities and the surface.

Horizontal layers of aspedin were described in the basal layer where primarily vertical canals characterize the vascular system.

This detailed study of Bryant confirmed most of Walcott's observations and clearly made the elements comparable to heterostracan plates as described by Stensiö (1932; fig. 69). Ørvig (1958) describes similar forms from the Upper Ordo-

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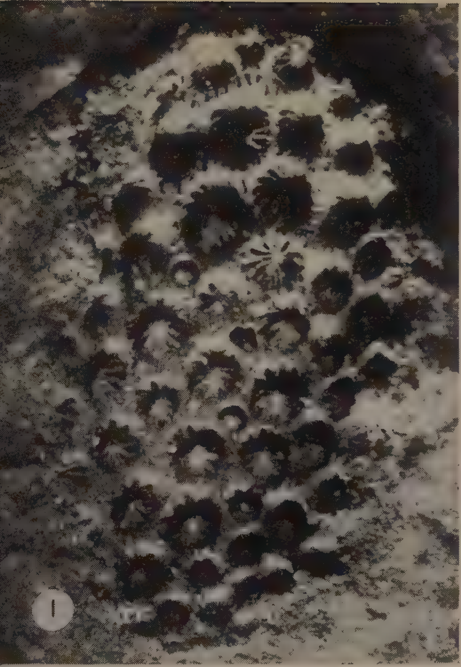
PLATE I. *Astraspis*

1. *Astraspis desiderata* × 14
   Bone removed. View of impressions of stellate caps as seen from medial aspect.
2. *Astraspis desiderata* × 14
   Bone removed. View of casts of reservoirs as seen from above.
3. *Astraspis sp.* and associated elements. × 9
4. *Astraspis sp.* × 30
   Thick section of angular plate with bone removed. The reservoirs are shown in position beneath the stellate cap impressions.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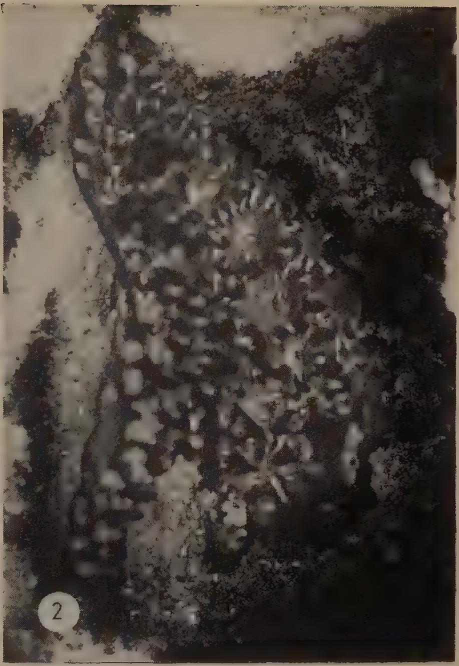
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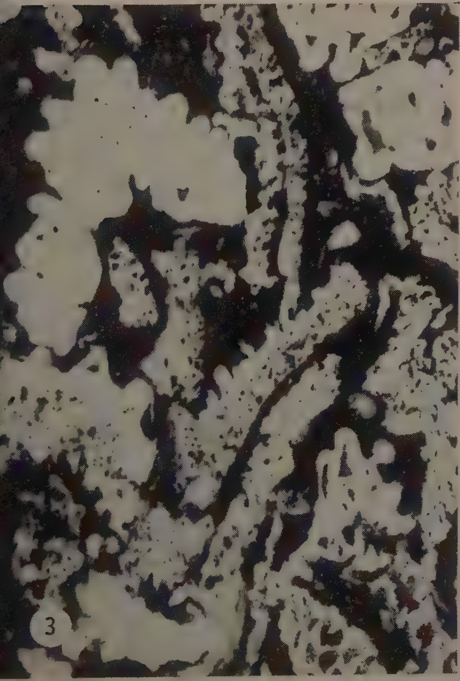
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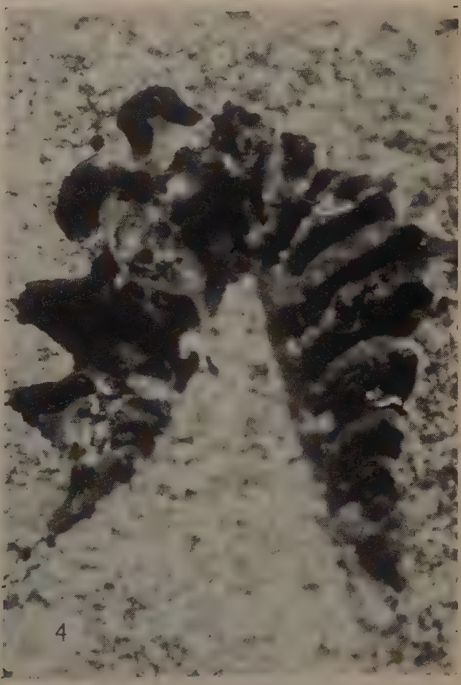
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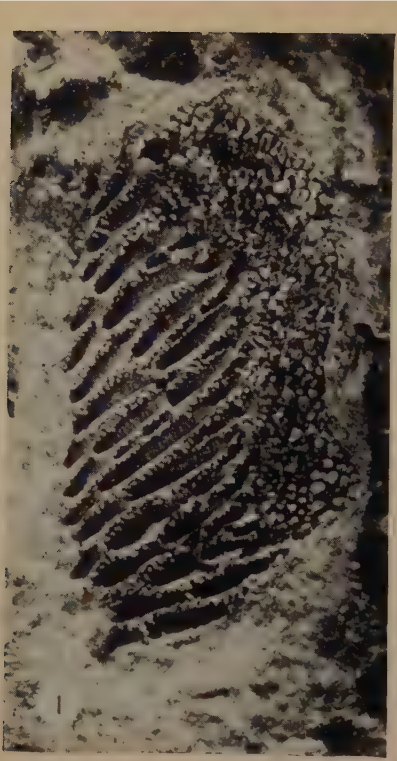
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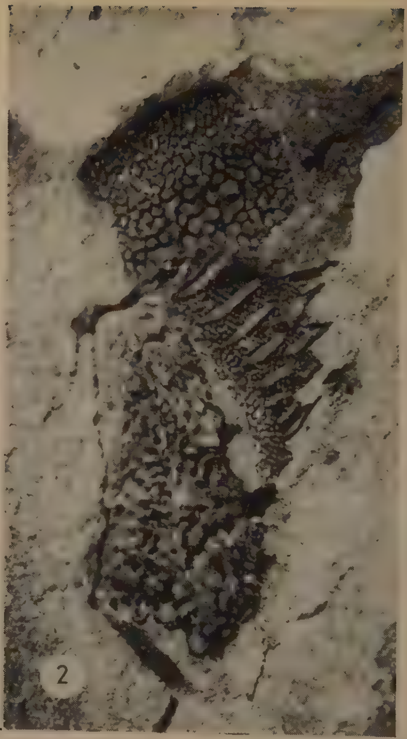
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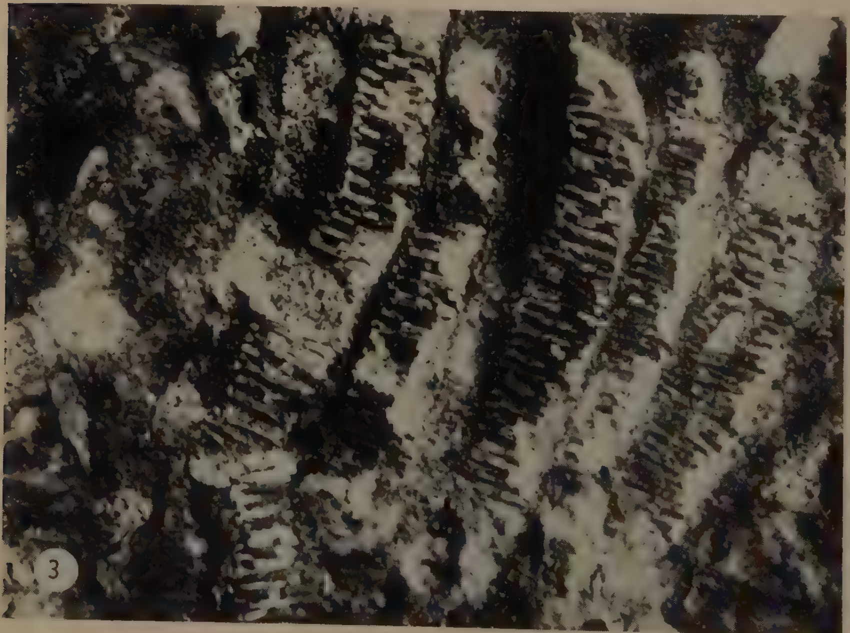
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vician of the Bighorn Mountains of central Wyoming, and his very clear drawings depict essentially the same microstructure noted by previous workers in the older Harding collections. *Pycnaspis splendens* (Ørvig, 1958) and the earlier described specimens of Walcott show the vertebrate exoskeleton to have attained a considerable state of complexity by Ordovician time.

Further collections from the type locality at Canyon City and environs permit some additional observations on the internal anatomy of the plates and scales and the demonstration of a small section of articulated material. This collection was studied by means of thin sections, acid etching and X ray diffraction analysis. The disposition of the scales and plates within the sandstones and siltstones suggests a relatively shallow bay zone (20-30 fathoms) for the former and a considerably deeper environment of deposition for the latter. Gould and Stewart (1956; figs. 2, 5) show shell and algal sand of dimensions similar to the Harding scales at the depths suggested. Since the least worn scales are present in shallower water, but beyond wave base, and the but

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PLATE II. *Eriptychius*

1. *Eriptychius americanus* × 11
   Bone removed. View of impressions of elongate dentine ridges and area of overlap as seen from within.
2. *Eriptychius americanus* × 10
   Bone removed. View of casts of elongate reservoirs and associated vascular structures as seen from above. Basal canals of another plate are seen in the upper central part of the photograph and poorly formed reservoirs of *Astrapis* in the lower center.
3. *Eriptychius americanus* × 5
   Five associated lateral body plates as seen from within. Dark, elongate impressions of dentine ridges are visible in the matrix. These are covered in some areas with the light-shaded bone.

slightly worn plates remain intact even in the fine sediments, it is assumed that *Astraspis, Eriptychius,* and associated materials were marine in habit.

Treatment of specimens collected at the Cripple Creek Shelf Road locality with five percent phosphoric acid resulted in the removal of the aspedin and the exposure of fine details of the negative impressions of sculpture, the extent and branching of the vascular channels, and the distribution and relations of cavities beneath the sculptured eminences. Negative impressions of the sculpture of *Astraspis* show the distinct stellate pattern with as many as sixteen rays in the larger tubercles, the number decreasing in the smaller stellae (pl. I, 1). Beneath the enameloid stellate caps and the supporting dentine base there are reservoirs which conform in distribution with the tubercles. These are connected with adjacent reservoirs, and vertical vessels extend to the surface of the plates around the tubercles (pl. I, 2). The reservoirs are connected to the base of the plate by the vertical channels which branch to meet the edges of the reservoirs as well as extending directly into the lower central portion of the reservoir (pl. I, 4). Thin sections frequently give the impression of a labyrinthine set of cavities in the reservoir areas. It is possible that these cavities were occupied by mucous secreted by underlying glands and also the channels were occupied by nutrient vessels and nerves serving peripheral structures such as chromatophores and sense organs.

Eriptychius (pl. II, 1; 2) in acid-etched specimens has clearly revealed negative impressions of the dentine eminences. These are surrounded by marginal vessels extending to the surface of the plate. Coarser vertical channels are present in the area of overlap which occupies the front third of the width of the element. The elongate cavities are replaced by siltstone and underly the eminences. These are not in communication with neighboring reservoirs and appear to be served with more numerous but less branched vessels than those described above for *Astraspis*. The mucous pores are emphasized in lines on some plates possibly showing the existence of a primitive lateral line. In some specimens there are channels of varying size in the area of overlap; some of these may have been occupied by connective tissue fibers functioning as connectors for adjacent elements.

Five imbricated body plates were found at the type locality in the Old Quarry one mile west of the city limits of Canyon City, Colorado. The largest is 1.3 cm. long and from 0.35 to 0.40 cm. wide, and the bone, including ornamentations, is slightly more than one millimeter thick. The anterior one third or more of the plate provides a surface for overlap which suggests the function of active mucous glands which may have provided a lubricant as well as a protective surface for the body. As illustrated, the armor is viewed from the inside. Much of the ornamentation has been lost but remains evident by the impressions registered in the matrix. Fragments of the bony base remain (pl. II, 3) and the aspedin is preserved between the adjacent plates to show clearly the direction of overlap.

The existence of the reservoirs and the complexity of the systems of channels show the bone to have enough surface exposed to the vascular system to serve as an effective calcium and phosphorous reservoir. The considerable surfaces for overlap suggest an active but well armored animal. The absence of carbonized or sulfide material in the specimens and the replacement of the cavities by fine siltstone exotically colored by oxides of iron is suggestive of a death assemblage which was not derived secondarily from an estuarine or fresh water source.

White (1958) argues the case for a marine distribution to account for the presence of later ostracoderms in contemporaneous beds in North America and Europe. *Archegonaspis* is from the Ludlow of Europe and the Salina of the United States. *Pteraspis* is reported from Europe, Spitzbergen, and Nova Scotia in the Lower and Middle Dittonian, and *Protaspis* from the Upper Dittonian and higher deposits in both Europe and the United States. Fresh water routes for this distribution can be obtained only be assuming continental connections or fresh water adaptations as a part of the life cycle.

White (1935, 1958) also convincingly assembles a series of pteraspids to show that the geologically earlier forms produced armor only after the full growth had been attained. Later heterostracans became ossified at more youthful stages in their life histories. Early pre-metamorphic stages of both the pteraspids and the osteostracids, as noted by Westoll (1945), may in instances have been characterized by a small animal devoid of armor. Certainly a considerable period of time was spent in the evolution of unarmored chordates and vertebrates and it is not unlikely that adaptations were early made to a fresh water habit. Clandestine evolution[11] may have been an important process in the very favorable nutritional conditions in barrier-guarded bodies of brackish water supplied by mineral-rich rivers. In such an environment in the early Paleozoic, accelerated growth rates and a hastened attainment of the reproductive capacity may have led chordates or primitive vertebrates into fresh water.

[11] De Beer (1954).

Concentrations of salts during conditions of drouth could create evaporite basins and the resulting conditions force the selection of another environment or result in the selection of halophilic developmental varieties. Anadromous or catadramous species thus originating could account for distributional patterns independent of marine or fresh water limitations. The modern cyclostomes so adapted may have early developed as successful carnivores near the start of fish evolution and thus have been a more effective factor than the eurypterids as a selective agency forcing the development of armor in the other less aggressive agnathids. Perhaps even now they present a fair portrait of an extremely successful early Paleozoic carnivore, just as *Branchiostoma* illustrates the marine status of the ancestral chordate.

The work of Webb and Hill (1958) shows patterns in the nutrition and development of this little chordate, which may now in our Pleistocene age of thermal and erosional cycles be experiencing some of the evolutionary stimuli gained only infrequently in the course of the earth's history. *Branchiostoma* was found to grow more rapidly, even to the point of attaining essentially adult size prior to the development of all of the branchial apertures, when living in a nutrient-rich lagoonal environment. The same species develops more slowly in seaward localities. Such growth patterns, if finally adaptive to other climatic conditions, could result in the selection of lancelets with neotenic tendencies in water of low salinity, a phenomenon suggestive of causal factors concerned with the early migratory habits of vertebrates.

Primitive visual pigments have been found by Wald (1957) in fresh water larval cyclostomes; a more advanced pigment was observed in the salt water adapted adults. If eyes were initially evolved in fresh water environments, as implied by Wald's work, then it is possible to theorize on a set of conditions to account for the closely set eyes of certain ostracoderms as a phenomenon indicative of fresh water adapted forms forced early in their evolutionary history into hypersaline environments. Stockard's (1921) experiments on *Fundulus* whereby he succeeded in the production of cyclopia on developmental stages grown in hypertonic solutions is suggestive of the effects on forms selected among the survivors of evaporite basins of the past. The widespread and ultimately more successful radiation of fish with relatively separated orbits implies a descent of the more conventional fishes from organisms which avoided this morphogenic trap.

The first development of the hard skeletal system was probably related to the visceral arches. Fibrous conodonts may well be the remains of stiffeners for a gill-sifting mechanism. As the primitive chordate or vertebrate increased in size, such structures may have developed into true branchial teeth. The most available chondrogenic and skeletogenic material probably existed in the head region in direct relation to the visceral arches. This mesectodermal tissue is derived from neural crest cells, and in the earliest vertebrates this embryonic source was probably concerned with the formation of the visceral arches and odontoblasts just as it is known to be in recent forms (DeBeer, 1947). Consequently, the early production of multi-layered armor in vertebrates of Ordovician age is not unexpected when embryological factors are weighed. The next step in the evolution of the hard parts would be the appearance anteriorly in the visceral arches of denticles with a resistant outer enameloid layer supported by dense dentine overlying a base of bone. Proliferation of such denticles outward to form a shagreen-like coat may have resulted in forms such as *Thelodus;* the dispersal of flattened plates could be the source of the armor in the Pteraspids. Individual denticles may have merged in other agnatha and lost their identity, but the individuality of the tubercles of *Astraspis* and the dentine ridges of *Eriptychius* with their attendant vascular and mucous supplies hark back to a simpler design.

Both sharks and the bony fishes have the same history of initially complicated scales and it is probable that the palimpsest of enamel, vitrodentine, ganoine, cosmine, dentine, and bone may likewise be understood by reference to the simple underlying history of the branchial denticles.

H. J. SAWIN

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